C. CHARACTERIZATION OF THE INEL ENVIRONMENT

1. Historical Background

The INEL is located along the western edge of the Upper Snake River Plain in southeastern Idaho as shown in Figure II-2. Lying at the southeastern foot of the Lost River, Lemhi, and Bitterroot mountain ranges, the INEL comprises some 571,800 acres, or 894 mi^2, of sagebrush covered land at an average elevation of 4,900 ft above sea level. The Snake River Plain is identified with the Pleistocene epoch, which began about 1 million years ago and is the most recent geologic time category. Fossils of prehistoric mammals have been found in excavations at the INEL. It is postulated that they are from camels and mastodons which inhabited the region during the latter part of the Pleistocene epoch about 35,000 yr ago. One fossil taken from carbonaceous strata encountered during well drilling at approximately 100 ft below land surface is over 40,000 yr old.

Recent archaeological investigations disclosed evidence that man has been in the region of Eastern Idaho for perhaps 10,000 to 12,000 yr. Fur trappers were the first known white men to enter the area now occupied by the INEL.

In the late 1870s, an east-west cattle trail crossed the INEL area. Large cattle herds were moved over this trail from Oregon eastward to markets and to ranges made available in Wyoming by treaties with the Indians. Two stagecoach lines also crossed the plain near the Twin Buttes, which long served as a landmark for early goldseekers. A branch of the Oregon Short Line railroad was constructed in 1910. Cerro Grande, now only a location name at the southern boundary of the INEL, was the end of the line until the rails were extended to Arco and to the mining town of Mackay.

An area within the INEL boundary was once a part of the Big Lost River Irrigation Project, one of the historically colorful reclamation projects in the West. It was authorized under the Carey Act of 1894, which provided that each state could be given land suitable for irrigation if the states did the reclaiming. Idaho accepted the application on the basis that private capital could be induced to construct the works and that the state would provide supervision. A dam on the Lost River was started in 1909 to provide storage to irrigate some 100,000 acres, 30,000 of which were known as the Powell Tract, which lies within what are now the boundaries of the INEL. Canals, ditches, and channel structures were constructed during 1910. The project was plagued with grave errors of engineering, financial difficulties, and legal and political controversies. Construction of the Powell Tract was discontinued in the spring of 1911. The old canals and structures are still prominent landmarks.

A similar project on the Little Lost River involved a small tract of land on the northwest side of the INEL. The Mud Lake Project in the northeast also included land within the INEL boundary. Both projects were the result of overly optimistic estimates. The dry canal systems are all that remain.

During World War II, the U. S. Navy utilized about 270 mi^2 of the plain for a gunnery range. An area southwest of the naval area was once used by the U. S. Army Air Corps as an aerial gunnery range. The INEL includes all the former military area and a large adjacent area withdrawn from the public domain for use by the ERDA and its predecessors. The former Navy administration, shop, warehouse, and housing area is still in use at the INEL.

The INEL was established in 1949 as a place where the ERDA could build, test, and operate various types of nuclear reactors, support plants, and equipment with maximum safety. Today the INEL is one of ERDA's principal centers for developing nuclear energy. It has the world's largest and most varied collection of reactors, including research, testing, power, and propulsion reactors. Although INEL planning in 1949 projected for possibly 10 reactors by 1964, 40 had been built by that time. As of December 1974, the number of INEL reactors built had reached 51, of which 17 were operating or operable. Three major acquisitions, as shown in Figure II-55, have resulted in a total land commitment for the INEL of about 571,800 acres (or 894 mi^2) since the initial transfer of the Naval Proving Grounds to the AEC.

Most of this large withdrawal of predominantly public domain lies in Butte County, Idaho, although it extends into Bingham, Bonneville, Jefferson, and Clark counties. The desertlike 894 mi^2 of the INEL is equivalent to more than 75% of the area of Rhode Island, the smallest of the 50 states. The location of the INEL in relation to the surrounding communities is shown in Figure II-1. Its location within Idaho with respect to the surrounding states is shown in Figure II-56.

2. Population

There are no populated areas within a 10-mile radius of the TRA-ICPP complex (a centralized location of nuclear facilities at the INEL). The nearest populated area to the INEL is Atomic City, located less than 1 mile from the southern INEL boundary, with about 75 residents. The population residing within a 30-mile radius of the TRA-ICPP approximates 1,500; and within a 50-mile radius approximates 69,000. The population distribution around the INEL, as a function of distance and wind direction frequency, is shown in Figure II-57.

Approximately 4,200 employees are present at the INEL during the day shift, and about 750 employees are onsite during each of the other shifts. These are average numbers that vary with changes in operational requirements and construction work.

No one is allowed to reside on the INEL. The permanent employees live in more than 30 communities adjacent to the INEL, the largest percentage in Idaho Falls. Contractor-operated bus service is provided from the major communities.

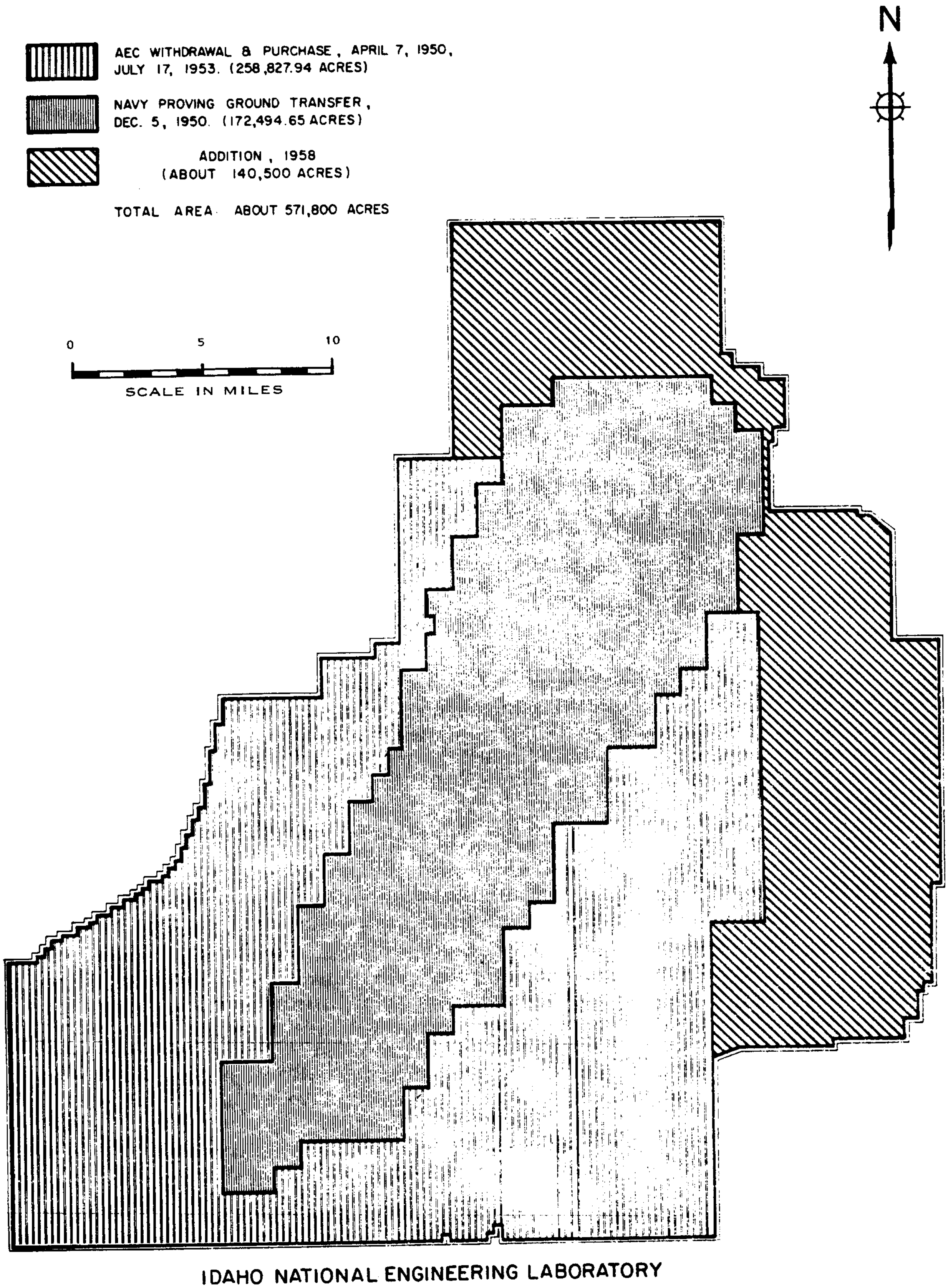


Figure II-55. Growth of the Idaho National Engineering Laboratory.

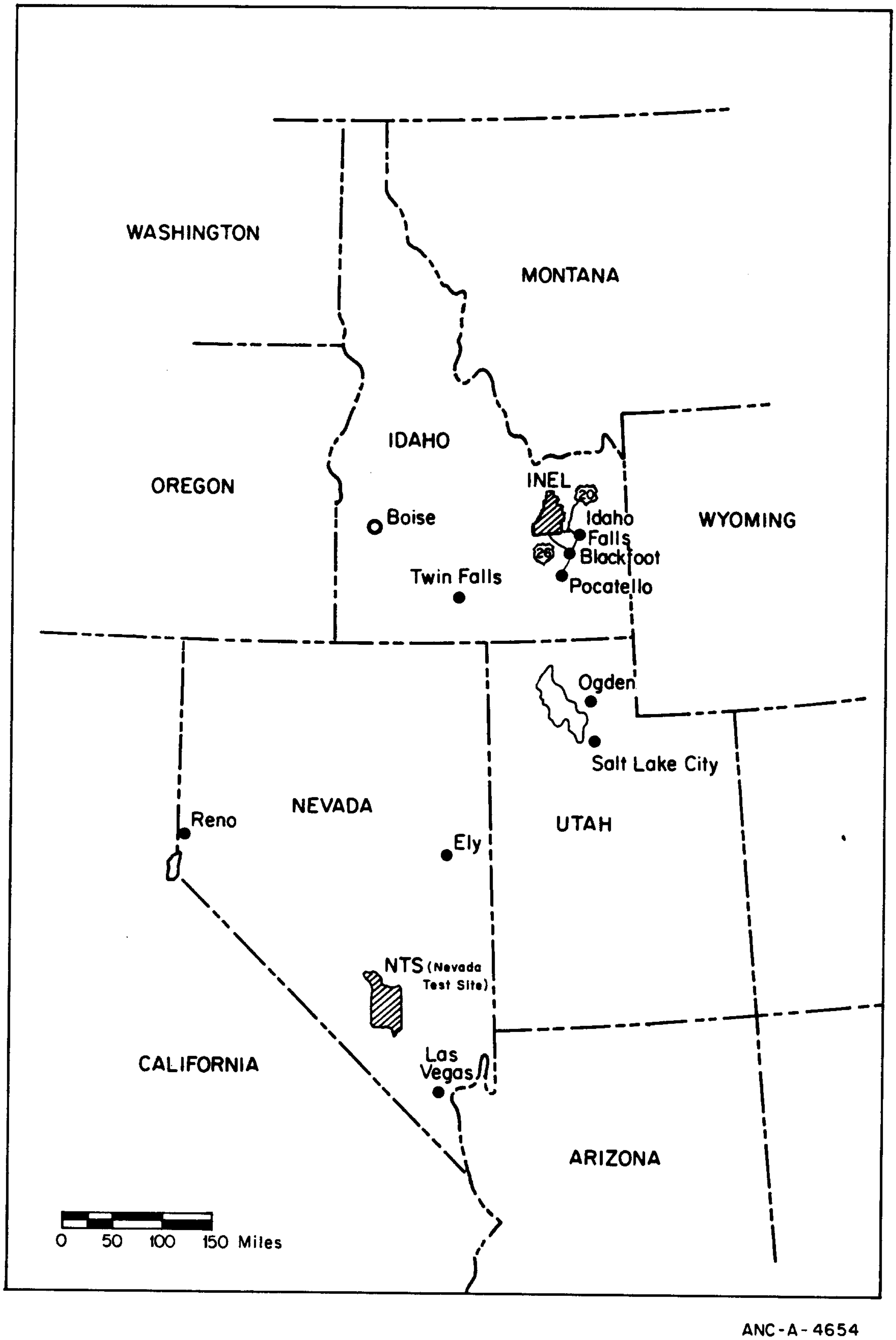


Figure II-56. Location Map of the INEL.

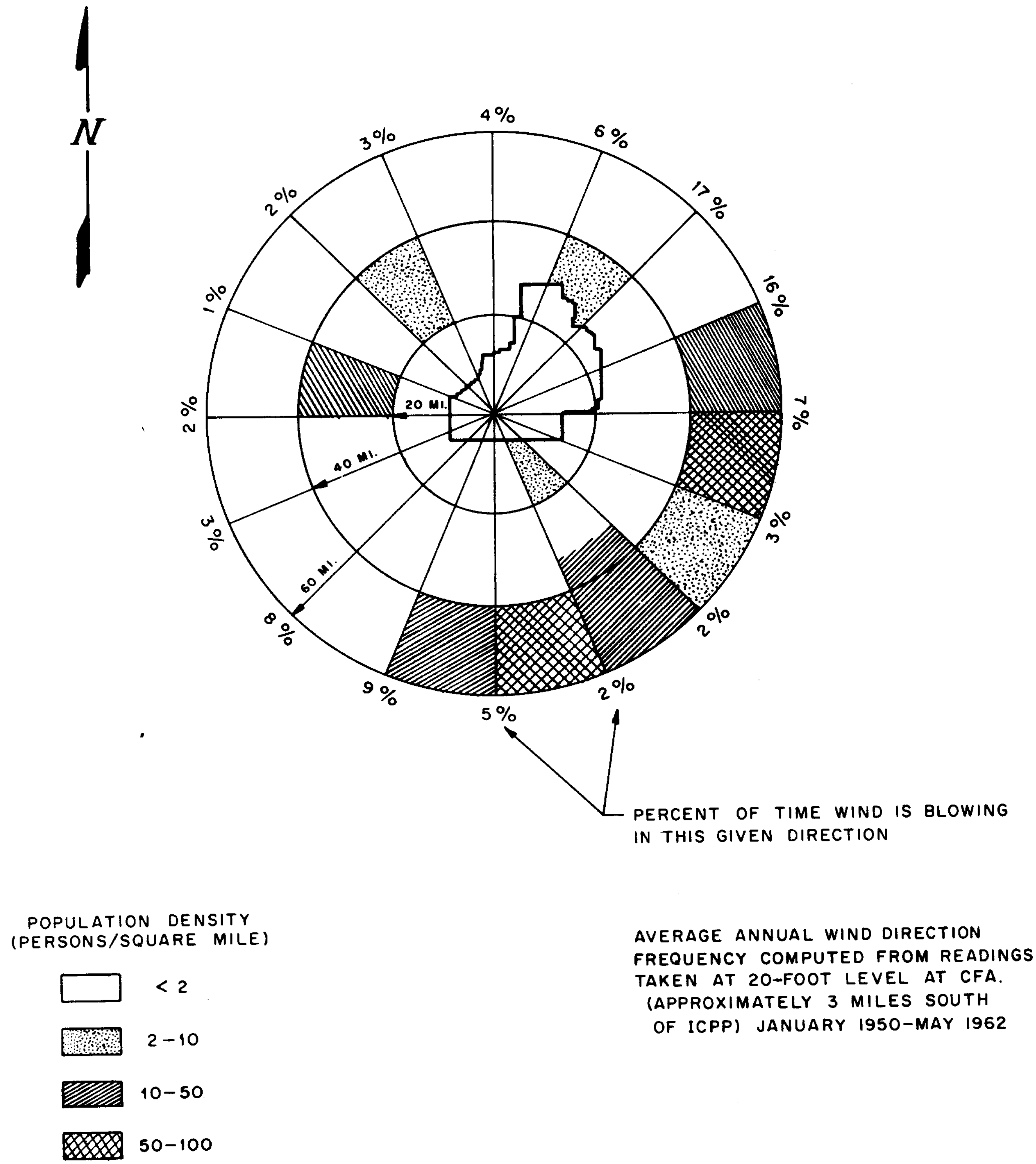


Figure II-57. Average Annual Wind Direction Frequency.

The growth characteristics of the cities and towns around the INEL are very similar to those of the rest of the state. According to the "Idaho Economic Atlas," published by the University of Idaho, the trend is for migration from rural to urban areas.

Idaho's least populous counties have out-migration rates several times greater than the most populous counties. For example, the urban increase from 1950 to 1960 was six times greater than the rural increase. This can be explained by the out-migration of young rural adults who have sought greater advantages elsewhere. The most mobile group (age 20 to 45) gravitated toward areas of greater economic opportunity, e.g., the cities and nearby towns; this mobility has changed the regional and local population densities. The net result of this migration trend on the INEL is that the population density movement is away from the station boundaries and toward the cities of Idaho Falls, Blackfoot, and Pocatello and some small towns nearby which are outside the 30-mile radius and in some instances outside the 50-mile radius. Table II-58 shows the growth rate of those counties

TABLE II-58

POPULATION GROWTH RATE OF COUNTIES WHICH ENCOMPASS INEL

County	1950	1960	1970
Bingham	23,271	28,218	29,167
Bonneville	30,210	46,906	52,457
Butte	2,722	3,498	2,925
Clark	918	915	741
Jefferson	10,495	11,672	11,740

which encompass the INEL, and Table II-59 shows the population change between 1960 and 1970 for those towns for which the information was available from the Idaho State Census.

3. Access

Four major all-weather roads service the INEL. The ERDA controls all access to the INEL. Public highways that traverse the INEL are patrolled by ERDA security forces, and traffic can be interrupted if necessary.

Although airlanes over the INEL are closed below 10,000 ft (mean sea level), commercial flights are allowed to pass over the INEL at elevations higher than 10,000 ft. However, a special air corridor over the station has been established between 7,000 and 10,000 ft. This corridor may be used upon receiving written permission from the Federal Aviation Agency (FAA) and ERDA in accordance with FAA regulations. Three commercial airports are situated within 100 miles of the INEL; one is 50 miles southeast in Pocatello; one, 29 miles east in Idaho Falls; and one, 80 miles southwest in Twin Falls. Several smaller, gravel surface landing strips near the INEL are used primarily

TABLE II-59

GROWTH RATE OF CITIES AND TOWNS AROUND INEL

POPULATION - OVER 1,000

City	1960	1970	% Change
Aberdeen	1,484	1,542	3.9
Ammon	1,882	2,553	35.7
Arco	1,562	1,244	-20.4
Blackfoot	7,378	8,716	18.1
Chubbuck	1,590	2,927	84.1
Idaho Falls	33,161	35,776	7.9
Pocatello	28,534	38,826	36.1
Rigby	2,281	2,311	1.3
Shelley	2,612	2,674	0.1

POPULATION - UNDER 1,000

City	1960	1970	% Change
Atomic City	141	24	-83.0
Basalt	275	349	26.9
Firth	322	362	12.4
Hamer	144	81	-43.8
Lewisville	385	468	21.6
Lost River	58	---	-100.0
Mackay	652	539	-17.3
Menan	496	545	9.9
Moore	358	156	-56.4
Mud Lake	187	194	3.7
Roberts	422	393	-6.9

for charter flights, crop dusting, etc.; the closest of these strips is located at Atomic City, near the south boundary of the INEL.

The Union Pacific Railroad crosses the southwest corner of the INEL and a spur line serves INEL facilities. The roads and spur line are shown in Figure II-2.

4. Land Use

The various nuclear facilities and numerous support facilities use only a small percentage of the total land area; they are widely separated and were sited deliberately for maximum safety. A large area of the INEL is used for grazing sheep in the spring and fall. About 600 acres have been seeded with crested wheatgrass, and usage is controlled by issuing of grazing permits. These areas are shown in Figure II-58. Grazing does not occur within 2 miles of any nuclear facility.

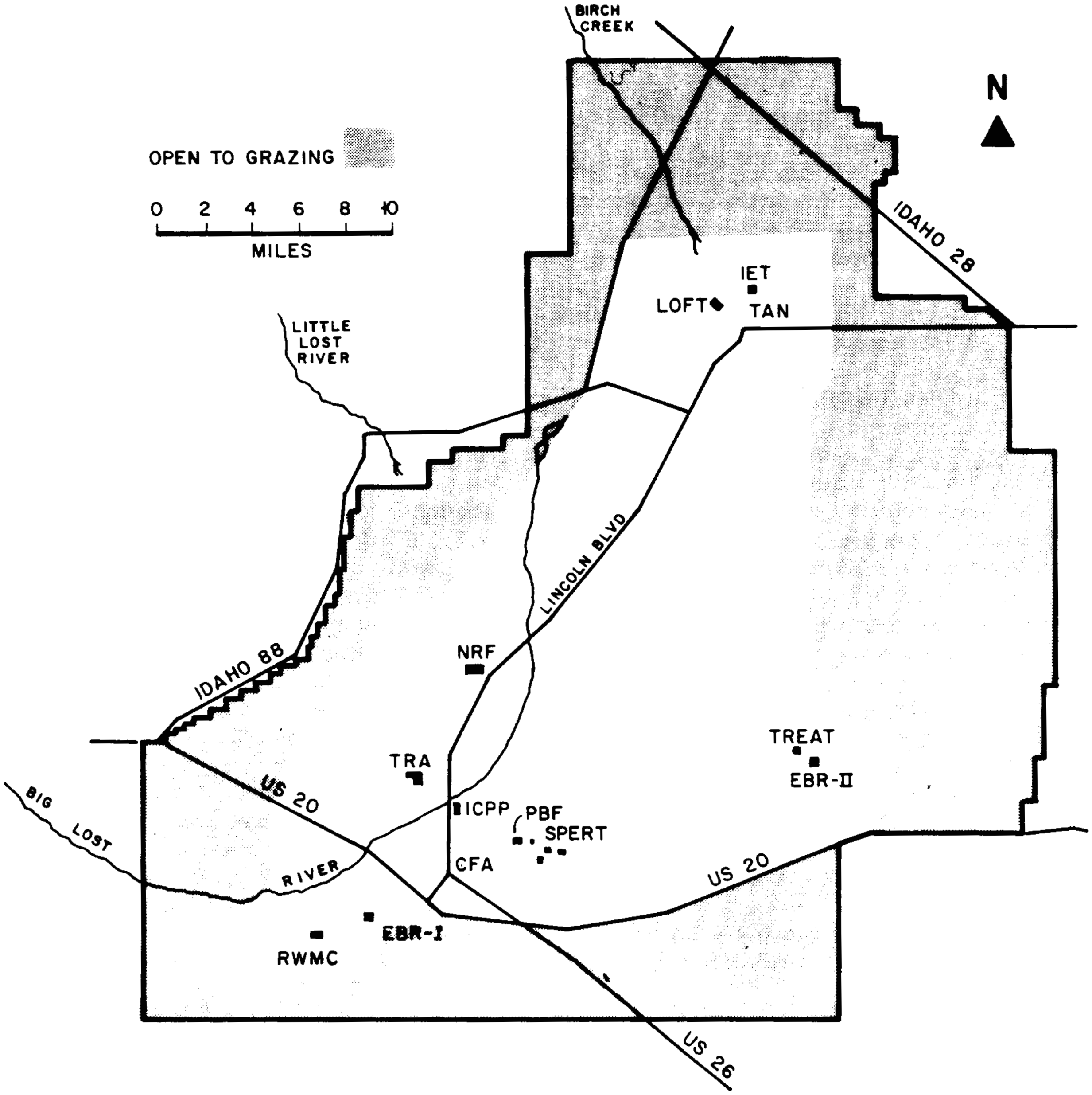


Figure II-58. Permit Grazing Areas Within the INEL.

5. Archaeology[a]

The INEL operating procedures prescribe measures for assuring protection of any antiquities or historic sites on the INEL, as required by the Antiquities Act of 1906 and the Historic Sites Act of 1936. These procedures are applied to avoid loss of archaeological and historical values found at the INEL. Archaeological surveys of the INEL were performed during 1967-1969 and again in 1970-1972. The locations and surveys of sites and the preservation of antiquities are continuing. Thus far, artifacts recovered from the INEL indicate that man has been present in the area over a long period of time ranging at least from the time of the mammoth hunters. These valuable sites are being protected from relic hunters, and this protection will be continued.

6. Topography and Climatology

The climate at the INEL is arid, assuming desert-like characteristics. The topographic features which affect the INEL weather patterns are the northeast-southwest orientation of the plain and the mountain ranges to the north and west. The Snake River Plain is relatively level, with an average elevation of 4,900 ft above sea level. To the north and west lie mountain ranges with elevations as high as 6,000 ft above the plain.

The National Oceanic and Atmospheric Administration (NOAA) has operated a meteorological observation program at the INEL since 1949. In addition to recording day-to-day weather data and providing daily operational forecasts for the INEL, the NOAA staff maintains an intensive research and development program to improve the reliability of prediction and measurement of meteorological parameters which influence safe conduct of operations on the INEL. A number of meteorological stations are located throughout the INEL to measure simultaneously the spatial variation of several meteorological parameters such as temperature, wind speed, and direction up to a height of 250 ft.

The location of the INEL on a broad and rather flat plain, the surrounding mountain ranges, the high altitude and the north latitude, all have a definite effect upon the climate as well as on the day-to-day weather. The orientation of the plain and its mountain-range walls tends to channel the prevailing west winds of this latitude so that southwest flow near the surface predominates over most of the INEL. Air masses entering the Snake River Plain first must cross over mountain barriers, where a large percentage of air moisture is precipitated. Yearly rainfall at the INEL is therefore light. The meteorological and climatological data are summarized in References 57 through 60.

a. Temperature

During the 22-yr period of record, the extremes of temperatures have varied from a low of -43°F in January to 103°F in July.

[a] Additional details are found in Section X, Part X.18.7.

During winter the average maximum temperature is approximately 27°F with an average minimum of approximately 3°F. The summer data indicate an average maximum temperature of 87°F and an average minimum of about 50°F. Normal weather conditions at the INEL develop lapse conditions during daylight hours and inversion conditions from about sunset until shortly after sunrise. Winds and clouds associated with stormy weather may prevent nighttime inversion. Daytime inversions may occur during the season of lowest sun angle, and later if snow cover exists. Annual averages show lapse conditions 52% of the time and inversion conditions 48% of the time.

b. Wind

The INEL is in the belt of prevailing westerly winds, which locally are channeled by topography into a prevailing southwesterly direction. During the summer months a very sharp diurnal reversal in wind direction occurs. Winds blowing from the southwest (upslope) predominate during daylight hours, and northeasterly winds persist at night. The reverse normally occurs a few hours after sunrise and again shortly after sunset.

The wind roses (Figure II-59), as measured at the CFA, are very similar for the four seasons; however, there is a fundamental difference between the winds in winter and in the other three seasons. Winter winds are controlled almost exclusively by either large scale weather systems or by stagnation, which show no significant diurnal characteristics. Winds in the other three seasons show diurnal characteristics in response to relatively strong local buoyancy forces resulting from heating of the local topography. The absence of this mountain-valley wind circulation in winter allows a high frequency of calms during periods of high atmospheric pressure.

The record of average wind speed shows a minimum of about 5 mph in December and a maximum of 9 mph in April and May. The highest maximum hourly average speed was 51 mph (measured at the 20-ft level at the CFA) from the west-southwest. Calm conditions prevail 11% of the time.

c. Precipitation

The average annual precipitation at the INEL is 8.5 in. Precipitation amounts are at a maximum during May and June, and fall to a minimum in July. There have been 13 occurrences of 1.0 in. of rain or more in a 24-hr period in the 22 yr of record. The greatest was 1.73 in. in June 1954. Only once has more than 0.5 in. of rain fallen in 1 hr, and that was 1.19 in. in 1 hr on June 10, 1969. Snowfall ranges from a low of about 12 in./yr to a high of about 45 in./yr. The average annual snowfall of 28.5 in. occurs primarily during the months of November through April, although snow occasionally falls during May, September, and October.

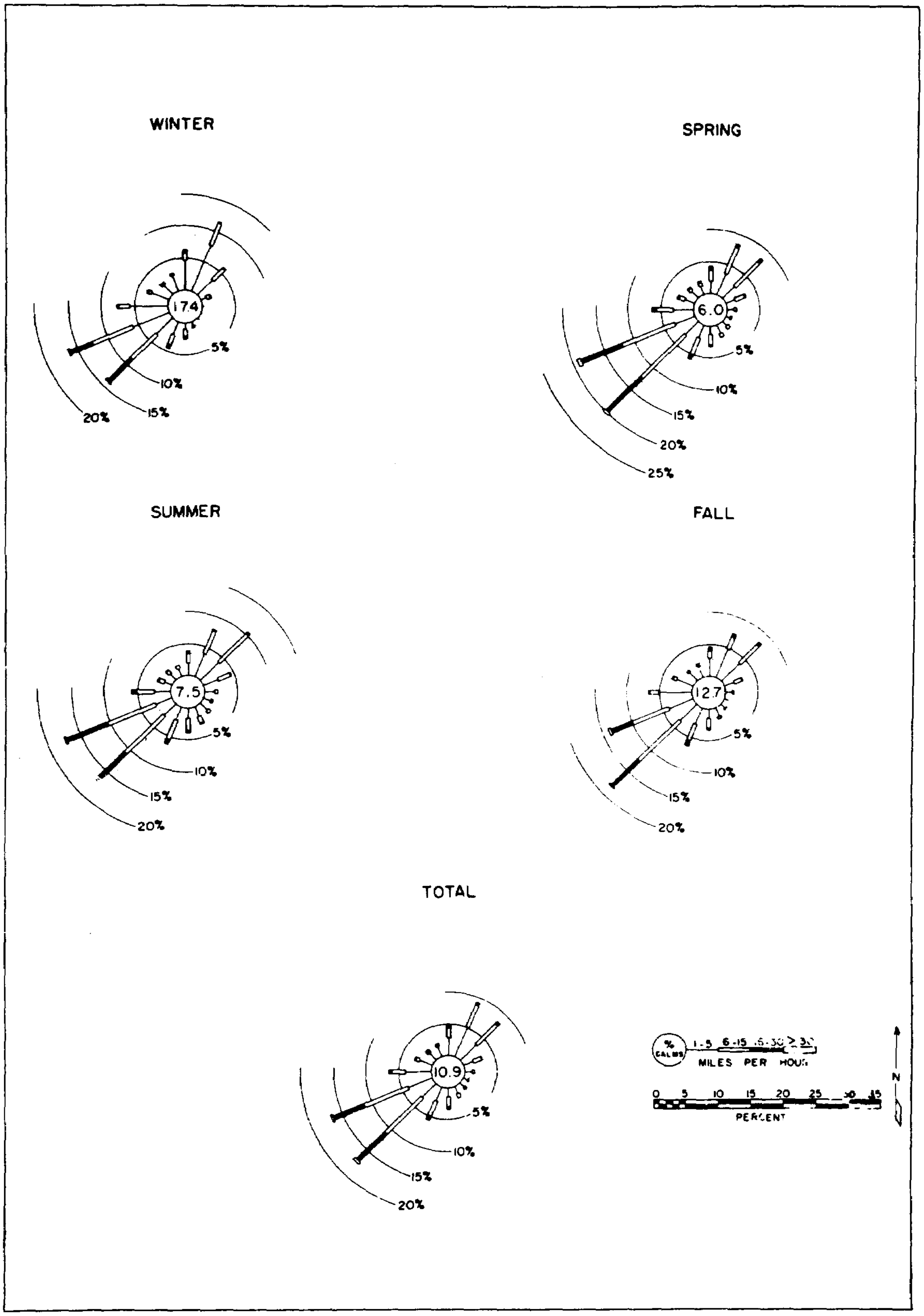


Figure II-59. CFA 20-ft-level Wind Roses (January 1950-May 1962).

d. Evaporation

While extensive evaporation data have not been collected on the INEL, evaporation information is available from Aberdeen and Kimberly in southeastern Idaho. These data, which should be representative of the INEL region, indicate the average annual evaporation rate is about 36 in. About 80% of this (29 in./yr) occurs from May through October.

e. Relative Humidity

The relative humidity at the INEL is quite low, with a monthly average minimum of 15% in August and a monthly average maximum of 89% in February and December. On a daily basis, humidity reaches a maximum just before sunrise at a time of minimum temperature, and reaches a minimum late in the afternoon near the time of maximum temperature. Large variations in relative humidity occur as a result of summer thunderstorms and large scale storms, predominantly from late fall through spring.

f. Severe Weather Conditions

On the average, two or three thunderstorm days occur during each of the months from June through August. The surface effects from thunderstorms over the Snake River Plain are usually much less severe than are experienced east of the Rocky Mountains or even in the mountains surrounding the plain. Strong wind gusts can occur in the immediate vicinity of thunderstorms. These gusts are usually quite localized and of short duration. The highest instantaneous speed recorded at 20 ft above the ground was 78 mph from the west-southwest. Although small hail frequently accompanies the thunderstorms, damage from hail has not occurred at the INEL.

Five funnel clouds (vortex clouds which do not reach the ground) and two tornadoes (which caused no damage) have been documented in the 23-yr period of observation at the INEL.

7. Geology[a]

The USGS over the past 35 years has studied the geology of the desert plain on which the INEL is located. The area occupied by the INEL has been intensively studied since 1949[61,62,62a,76].

The Snake River Plain cuts a 50- to 100-mile-wide swath through the Rocky Mountains across the State of Idaho. The 12,000-ft-high peaks of the adjacent snow tipped mountains are a sharp contrast to the plain which rises gently from 2,300 ft in the west to 6,000 ft in the east. Bordering ranges consist of Paleozoic and Mesozoic rocks folded and later uplifted along normal faults during Basin and Range tectonism. These ranges terminate abruptly against both sides of the low lying basalt and sediment filled Snake River Plain. A narrow strip of green vegetation runs along the banks of the Snake River, from which irrigation makes farming practicable; and clumps of dry gray sage, interrupted by hummocks of glistening black basalt flows, cover the plain.

[a] Additional details are found in the response to Comment X.18.3, Section X.

Located entirely on the eastern Snake River Plain, the INEL adjoins mountains to the northwest that comprise the northern boundary of the plain. Except for small areas along the mountain fronts and three rhyolite domes, all approximately 500,000 ±200,000 yr old, the entire INEL area is underlain by a succession of Pliocene, Pleistocene, and recent basaltic lava flows. The basalt is formed chiefly from fluid, (low viscosity--approximately 1 poise), high temperature (900-1,200°C), pahoehoe type lavas. The flows have been extruded from rifts and from volcanoes whose locations are rift controlled. These form layers of hard rock of varying thickness from 10 to 100 ft. The physical characteristics and horizontal distribution of the flows also vary. Unconsolidated material, cinders, and breccia are interbedded with the basalt. The beds are nearly horizontal, with no significant structural deformation evident. The 9.3 mile-wide Arco Rift Zone extends 31 miles southeastward from the north margin of the Snake River Plain at Arco to the longitudinal axis of the plain near Atomic City. The Arco Rift Zone is the locus of extensional fractures, a graben structure, rifts, and numerous basalt volcanoes. The youngest basalt flows in the Arco Rift Zone, Cerro Grande and North Robbers, are 10,780 ±300 and 11,940 ±300 carbon-14 yr old respectively. These layers have been penetrated by drilling to a depth of 1,497 ft. On the basis of geophysical and geologic evidence gathered from surrounding areas, the depth of these layered deposits is inferred to range from less than 1,000 ft to more than 5,000 ft. It is inferred also that these rocks are underlain by geologically older volcanic and sedimentary rocks, perhaps ranging from Cambrian to Tertiary ages. Rhyolitic volcanic rocks of caldera origin, ranging in age from approximately 4 million to 10 million yr, are exposed along the north and south margins of the eastern Snake River Plain and these rocks are presumed to underlie basalt beneath the INEL. The most recent volcanic activity in the region occurred at the present site of the Craters of the Moon National Monument, approximately 25 miles southwest of the INEL, about 1,500 to 2,000 yr ago.

The youthfulness of volcanic rocks in and near the RWMC has made desirable an assessment of the possibility of volcanic and seismic hazards to the facility. For this reason, geologists of the U. S. Geological Survey working in the region have been funded by ERDA-INEL to investigate these questions. Although the investigation is still in progress, sufficient data have been accumulated to support the following points:

a. Based on data available December 1976, the RWMC lies within a young volcanic-tectonic feature, the Arco Rift Zone. The recurrence interval of volcanic eruptions, faulting, and possibly earthquakes in the Arco Rift Zone is estimated at approximately 10,000 yr.

b. Even though the Snake River Plain appears to be aseismic on the basis of historical earthquake records, the presence of rifts, extensional fractures, and probable fault scarps in the Arco Rift Zone and the fact that earthquakes generally accompany present day volcanism in other parts of the world suggest that earthquakes may have occurred in and near INEL in the past. Data are currently judged to be insufficient to estimate their past frequencies of magnitudes.

The southern and eastern perimeters of the basin are formed by elevated ridgelike structures. These features have intercepted the Big and Little Lost Rivers and Birch Creek, diverting them into playa-like depressions on the INEL where their waters are dissipated by seepage and evaporation. The surface soils and regolith along the streams are made up of alluvial sands and gravel of varying thickness. These grade into finer textured sediments toward the terminal ends of the streams. The surface soils over the remainder of the INEL are formed by eolian and loessal deposits of varying thickness. Sandy soils derived from windworked beach and bar deposits formed in old playa lakes or ponds are especially common in the northern part of the INEL. In many places, the basalt is not covered. Local playa areas contain deposits 10 to 15 ft thick. Alluvial fans occur along the mountain fronts. A general geologic map of the INEL and eastern Idaho is shown in Figure II-60.

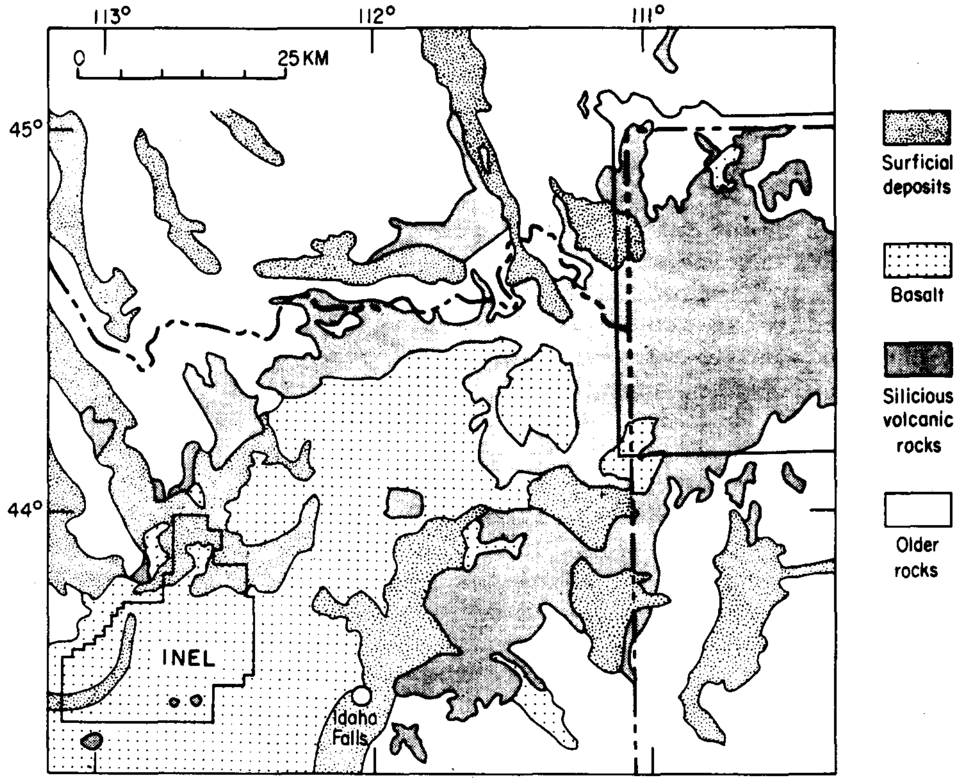


Figure II-60. Generalized Geologic Map of the Eastern Snake River Plain, Idaho and Vicinity.

The fraction of the soil less than 2 mm in size has the capacity to sorb radioactive ions. This size fraction consists of quartz, calcite, feldspar, dolomite, montmorillonite, and hydromica (illite). The cation-exchange capacity has been determined and formulae have been developed for estimating the amount of radioactive cesium and strontium which will be sorbed under given circumstances[63]. The capacity to retain or sorb cesium is considerably higher than for strontium.

8. Seismology

Prior to 1970 the INEL was classified in Seismic Zone 2 of the Uniform Building Code of the International Conference of Building Officials[64]. In 1970 the classification was changed to the higher-risk Zone 3[65]. The seismic zones for the United States are shown in Figure II-61. This action imposed more stringent design criteria on facilities constructed after April 1970.

Between 1884 and September 16, 1963, 53 earthquakes equivalent to Modified Mercalli Intensity (MMI) V or greater were recorded in Idaho. Of these, 29 are listed by the U. S. Coast and Geodetic Survey[66] as having originated (epicenter) in Idaho. Another 14 earthquakes of this MMI range are recorded in the NOAA's Hypocenter Data File as having epicenters in Idaho since September 16, 1963. No destructive quake has been recorded to date in the eastern part of the Snake River Plain (Figure II-62). The most recent regional earthquake that was accompanied by severe surface faulting occurred August 17, 1959, near Hebgen Lake, Montana, about 100 miles northeast of the INEL. This quake produced an intensity of V to VI (shown in Figure II-63) within the INEL, but caused no damage to facilities[67].

Two faults along mountain fronts north of Arco and Howe, a few miles from the INEL boundary, are relatively recent (within the last 1 million yr) and are evidenced by fault scarps. These scarps indicate aggregate displacements (occurring in several episodes) of from 40 to 50 ft. The Arco and Howe fault scarps probably have been formed in the last 30,000 years, possibly more recently than 10,000 yr; movement even in the last 4,000 yr cannot be discounted[68].

A nine month study of microearthquakes in the vicinity of the INEL was conducted by the USGS in 1968-1969 to determine whether the Arco-Howe faults, or possibly others in the region, are sources of microearthquakes. No seismic activity was detected in the vicinity of the INEL. The study concluded that the eastern Snake River Plain in the vicinity of the INEL is currently aseismic; however, the absence of microearthquakes does not eliminate the possibility that the earth's crust in this region contains stored elastic strain that might be released, by slippage along a dormant fault, to produce an earthquake.

Since October 1972, the ERDA-ID has operated a network of three vertical motion recording seismographs: one located at CFA and the other two off the plain -- one at Howe Peak (northwest of the INEL) and the other on Taylor Mountain (southeast of Idaho Falls). Data obtained to date tend to indicate that the Snake River Plain is aseismic and seismically "decoupled" from the mountains surrounding it. It appears, at least preliminarily, that damaging seismic waves may be filtered out or rapidly attenuated in the geologic structures of the plain. The present seismograph network is capable of detecting microseisms from strain accumulation along faults in the mountains. It also will detect any microseisms on the eastern Snake River Plain which would precede a resumption of volcanism[69].

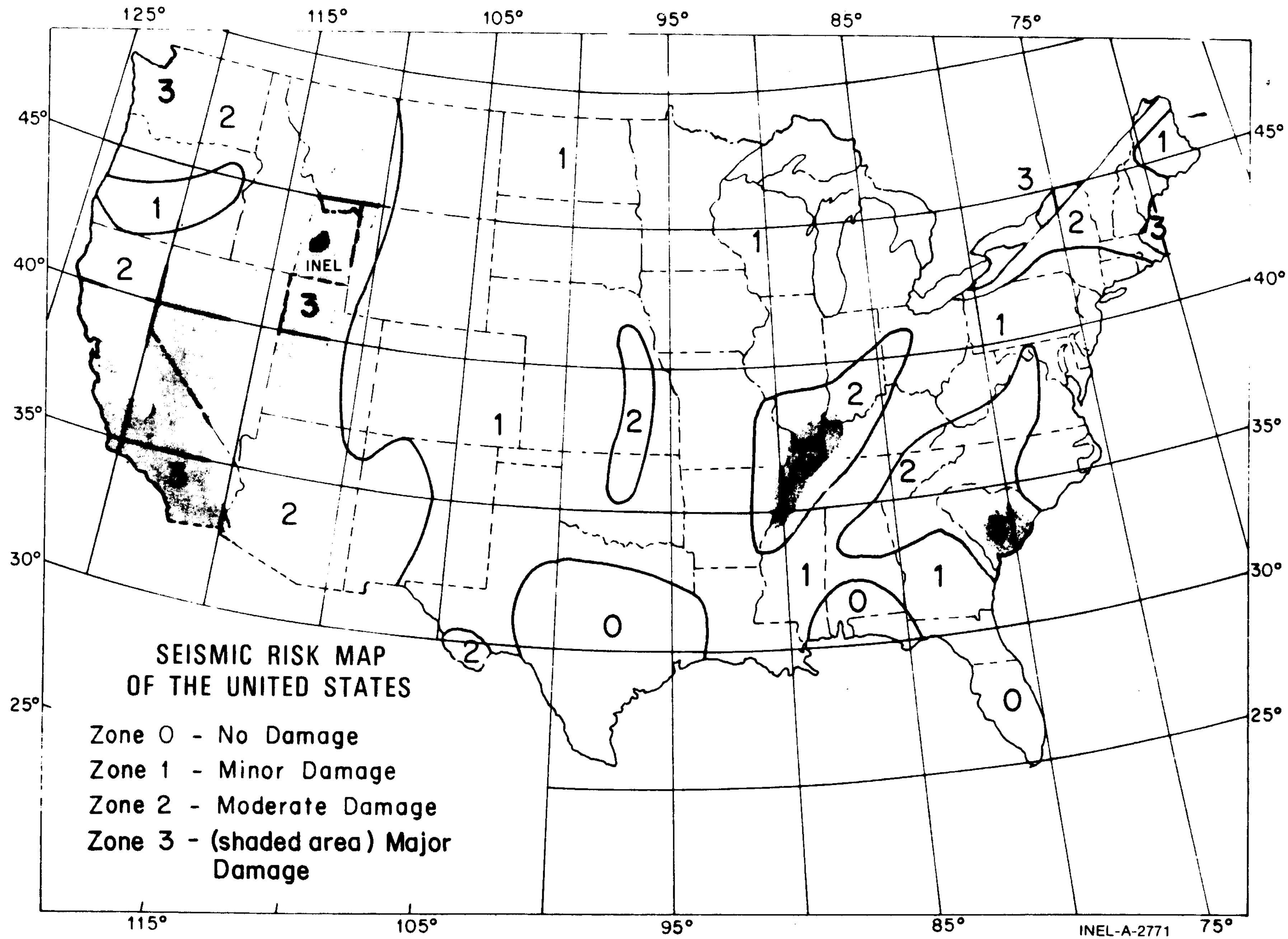
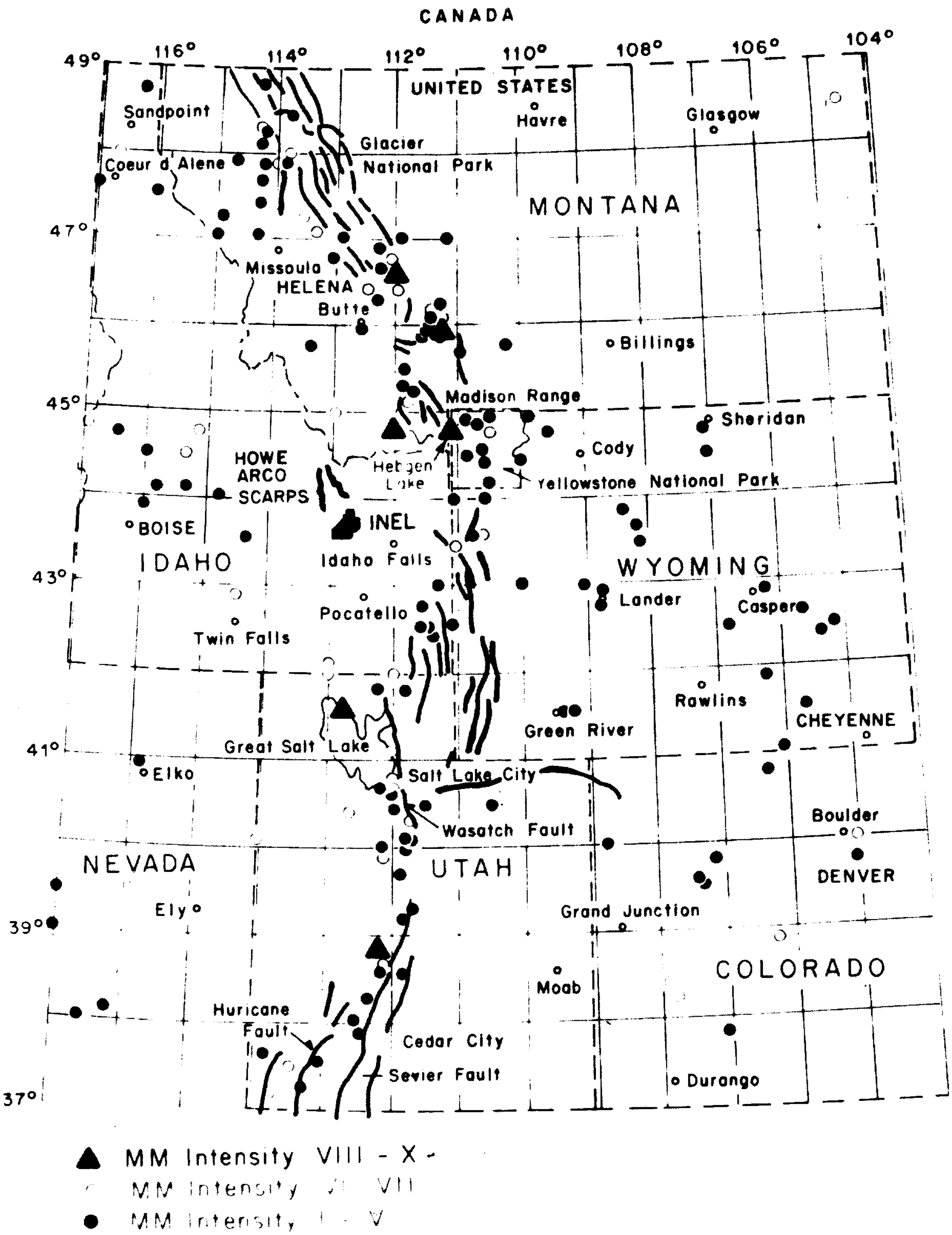
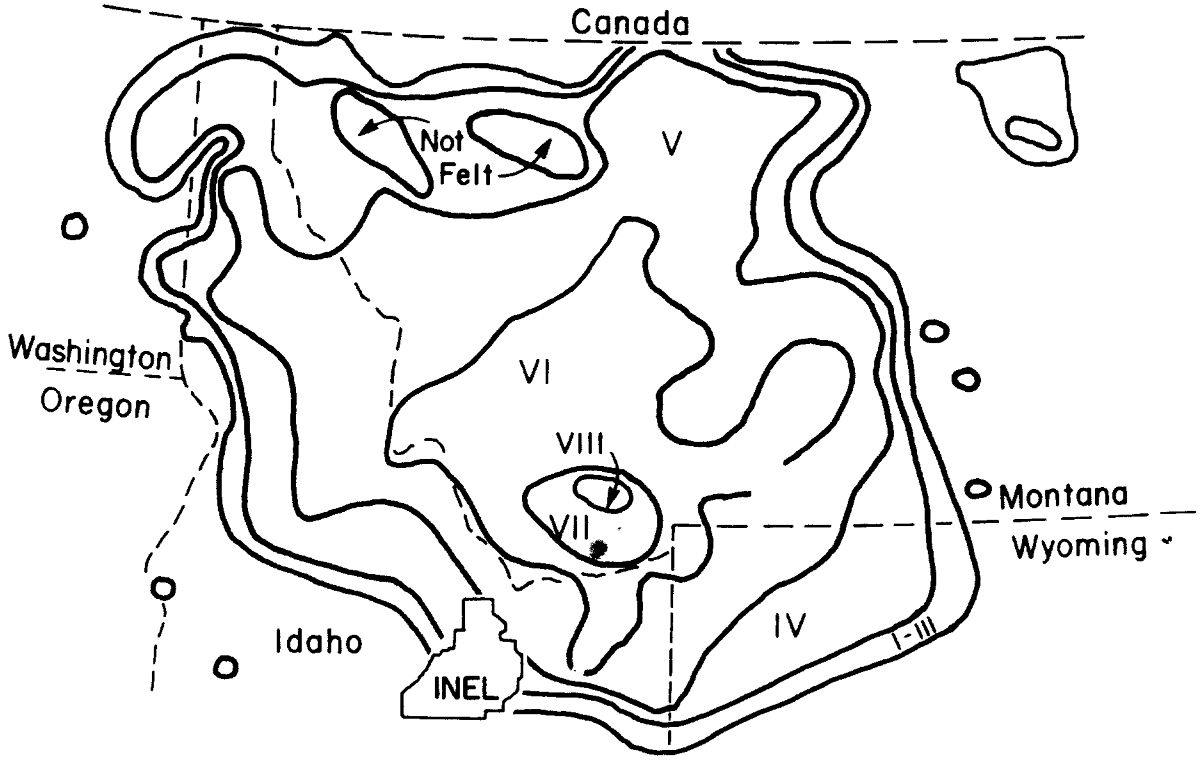


Figure II-61. Seismic Risk Map of the United States.

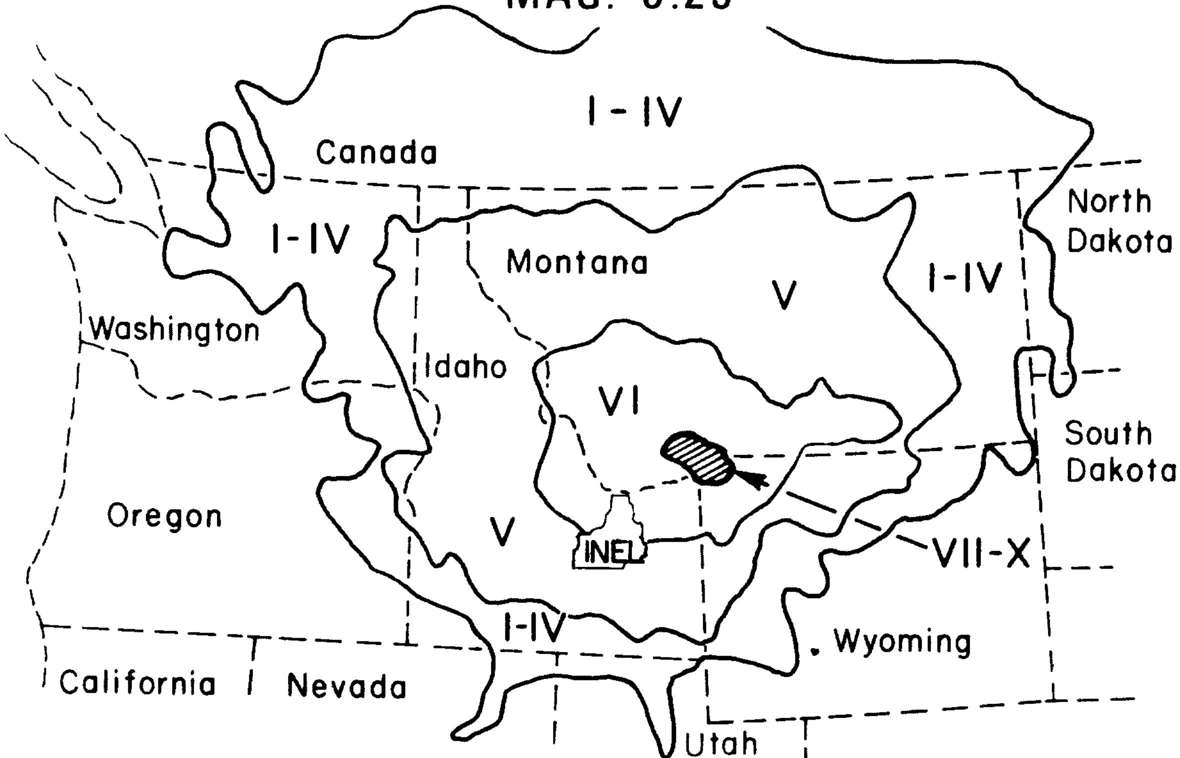


MAP SHOWING EARTHQUAKES REPORTED FROM THE ROCKY MOUNTAIN REGION AND ADJACENT AREAS FROM 1869 THROUGH 1954, INCLUDING THE HEBGEN LAKE EARTHQUAKE OF AUGUST 17, 1959
(Seismic data from publications of the U. S. Coast and Geodetic Survey.)

Figure II-62. Seismic Characteristics of Intermountain Region.



ISOSEISMAL MAP
MONTANA EARTHQUAKE, NOVEMBER 23, 1947
MAG. 6.25



ISOSEISMAL MAP
EARTHQUAKE OF AUGUST 17, 1959, MAG. 7.1

Figure II-63. Isoseismal Map of Two Regional Earthquakes.

Recently (1976) the USGS prepared an open file report entitled "A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States."

This report presents a probabilistic estimate of the maximum ground acceleration to be expected from earthquakes occurring in the contiguous United States. It is based primarily upon the historic seismic record. Geologic data, primarily distribution of faults, have been employed only to a minor extent, because most such data have not been interpreted yet with earthquake hazard evaluation in mind.

The principal map in this report provides a preliminary estimate of the relative hazard in various parts of the country. The report provides a method for evaluating the relative importance of the many parameters and assumptions in hazard analysis. The map and methods of evaluation described reflect the current state of understanding and are intended to be useful for engineering purposes in reducing the effects of earthquakes on buildings and other structures. The maps show the acceleration (given in percent of the acceleration of gravity) in hard rock with 90% probability of not being exceeded in 50 yr. That is, there is only a 10% probability of these values being exceeded in 50 yr. The map has contour levels which range from 0.04 g to 0.60 g. Below the 0.04 g contour level the ground shaking effects are largely controlled by earthquakes with magnitudes of 4.0 or less. Events of this size are incompletely recorded and it is difficult to estimate the recurrence rates for earthquakes of these magnitudes or smaller. Furthermore, it is likely that suitable attenuation functions will not produce accelerations larger than 0.04 g except in the immediate vicinity of the event. This limits their impact in the hazard calculation. In those regions of the map below the 0.04 g contour (such as the INEL), wind loading of structures is expected to be the governing factor in the design of structures, so that earthquake shaking, at the level of hazard assumed, is not likely to be important.

The usefulness of the horizontal acceleration map is not so much in the absolute values of acceleration mapped but primarily because it provides insight into the relative hazard across the United States together with results concerning the relative importance of the various parameters involved. On this map, the horizontal acceleration is less than 4% of gravity over all of the INEL. Therefore, this map shows that the INEL is classed in an acceleration area which is as low as any area in the United States.

The 1970 Uniform Building Code listed the INEL in Zone 3, based primarily on the Hebgen Lake earthquake of 1959. All the later studies seem to provide data and interpretations which suggest that the plain is rather aseismic. However, the Snake River Plain is certainly not free of seismic risk but all the factors suggest less risk than Zone 3.

9. Hydrology

Since the Snake River Plain is semiarid, groundwater is a resource of primary interest. This groundwater is discharged at large springs in the valley of the Snake River about 125 miles southwest of the INEL. Wells on the INEL tap this aquifer system, and although large quantities of water are pumped out, pumpage from the wells is only a very small percentage of the water available. Withdrawals for irrigation are large in other parts of the plain but not in the vicinity of the INEL.

a. Surface Water

Surface water at the INEL consists mainly of streams draining through intermountain valleys to the northwest. The major streams are the Big Lost River, Little Lost River, and Birch Creek, all shown in Figure II-64. Local spring runoff in other parts of the station also can be significant at times. Most of the INEL lies within the Pioneer Basin, a closed topographic depression into which the three above mentioned streams drain. The termination for the three drainages is the Birch Creek playa in the north-central part of the INEL (Figure II-64).

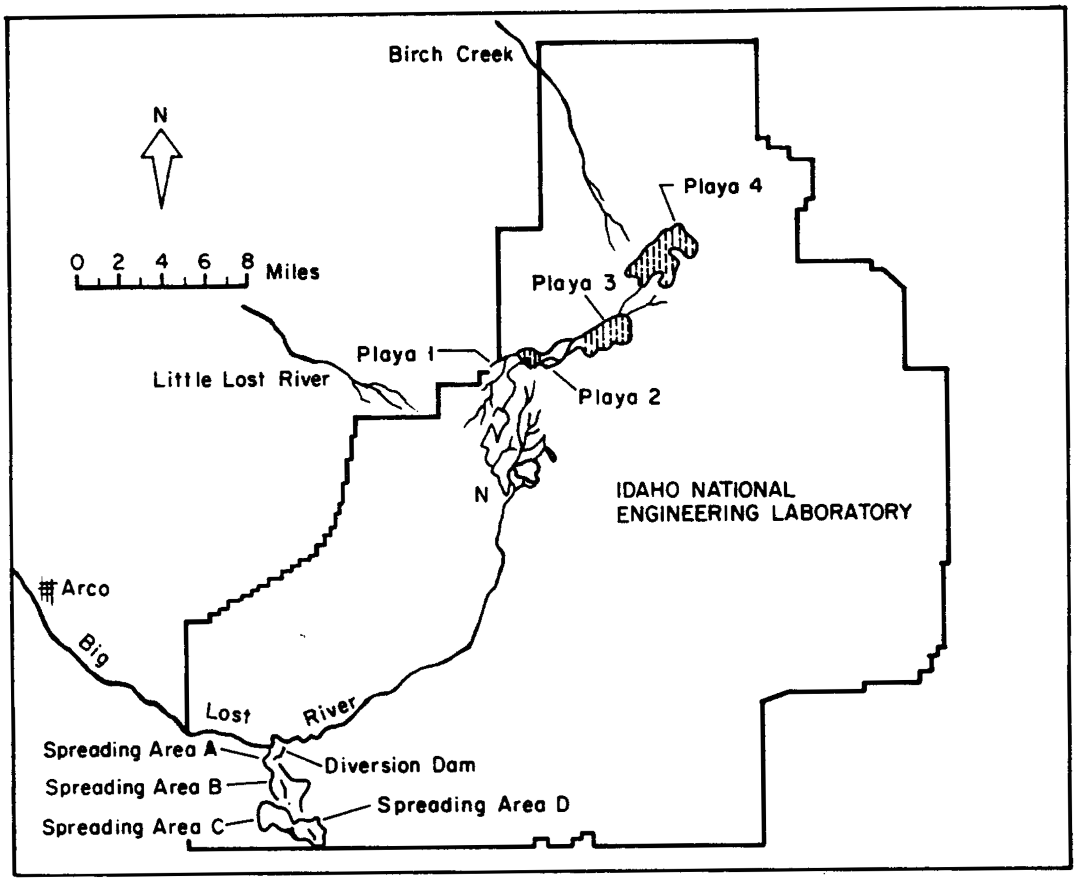


Figure II-64. Map of the INEL Showing the Big Lost River System.

The Big Lost River is by far the most important element of the surface water hydrology. Flows from the Little Lost River and Birch Creek very seldom reach the INEL, whereas the Big Lost River has carried a significant discharge onto the INEL from 1965 through 1974. Except during years of extremely high runoff, all flow from the Little Lost River and Birch Creek is diverted for irrigation before it reaches the INEL or the terminating playas. The average discharge of Little Lost River, 7 miles northwest of Howe, is about 50,000 acre-feet/yr or 70 ft^3/sec. The average discharge for Birch Creek is about 57,000 acre-feet/yr (79 ft^3/sec) near Reno, Idaho. For comparison, the Big Lost River discharges an average of 210,800 acre-feet/yr (291 ft^3/sec) below Mackay Dam, 30 miles northwest of Arco. The flow of Birch Creek is remarkably uniform because it is primarily fed by groundwater inflow. During periods of extremely rapid thawing and runoff, such as happened in the early spring of 1969, water from the Birch Creek drainage can become a flood threat to facilities at TAN. The high runoff in 1969 was caused almost entirely from rapid snowmelt on the lower reach of the Birch Creek valley, not from the discharge of Birch Creek. The flow over Highway 22 was estimated to be about 500 ft^3/sec in April 1969. Some of the flow was diverted into two nearby gravel pit excavations. Low earthen dikes were bulldozed around the Loss-of-Fluid Test facility and adjacent construction areas. Some sandbags were filled and placed around the facilities. Little damage to INEL facilities was sustained as a result of these emergency preventative measures. The entire flow of Birch Creek is usually diverted from Birch Creek valley to the east to be used on Reno Ranch. Some of the flow is not diverted in the winter because of ice flooding conditions in the channel. The winter flow in the main channel flows onto the INEL and is ponded by playas ("sinks") several miles to the north of the facilities. Information available does not permit a classification of the 1969 snowmelt flood into a flood recurrence interval.

The maximum recorded discharge of Birch Creek near Reno, Idaho was 220 ft^3/sec on April 1, 1962. The minimum discharge was 50 ft^3/sec on January 12, 1963. The average discharge was 79 ft^3/sec for 15 yr of record.

Birch Creek and Little Lost River have a minimal effect on INEL hydrology. Therefore most of the interest in surface water at INEL is directed toward the Big Lost River.

The Big Lost River flows southwestward down the Big Lost River valley past Arco and out onto the Snake River Plain, turning northward through the INEL to its termination in playas 1, 2, and 3 (Figure II-64). After entering the plain, the river continually loses water by infiltration through the channel bottom and sides. Therefore the distance to which flow is carried in the channel depends on the discharge and infiltration conditions. At times flow does not even reach the INEL, and at others it continues as far as playa 3. If playa 3 fills to capacity, it overflows into Birch Creek playa, playa 4. As flow approaches playas 1 and 2, the channel branches into many tributaries, and the flow spreads over several flooding and ponding areas.

The maximum discharge, recorded to date of the Big Lost River occurred October through September in water year 1965 (397,000 acre-feet below Mackay) and the average for 57 yr of record is 210,800 acre-feet/yr (Figure II-65). The effects of the 1965 record flow are discussed in detail in a previous report[70]. A detailed analysis[71] has been made on the probability and potential of snowmelt floods exceeding the capacity of the INEL flood diversion system. This

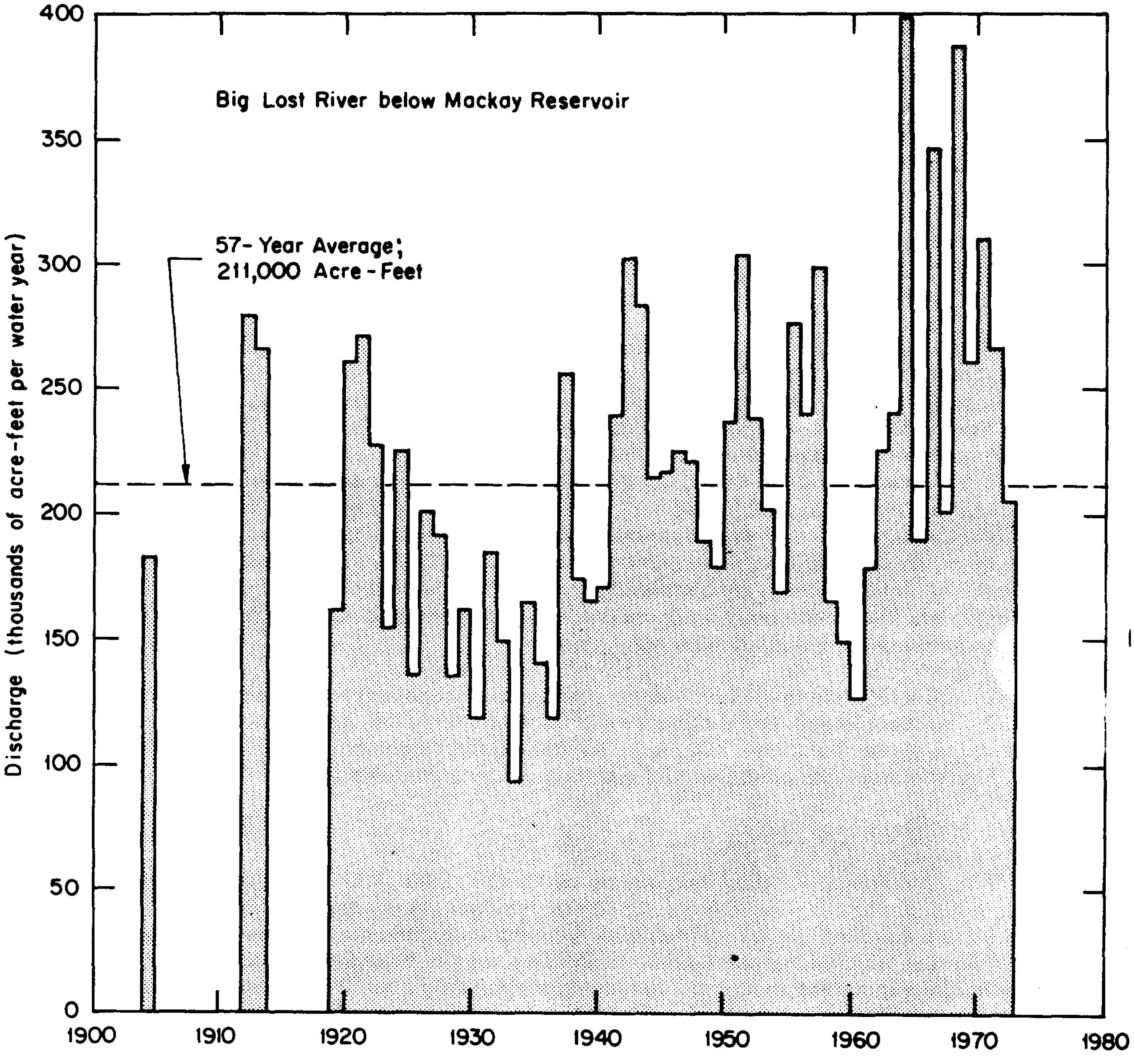


Figure II-65. Graph Showing the Yearly Discharge of the Big Lost River below Mackay Reservoir.

study investigated selected sites on the Big Lost River, determined stage discharge relations for these sites, and prepared rating curves. Flood hydrographs were modeled and synthetic floods were routed until the flood exceeded the capacity of the selected site.

For the Big Lost River below Arco, Idaho, the 15-yr flood is determined to be 2,610 ft^3/sec, the 20-yr flood is 2,800 ft^3/sec, and the 50-yr flood is 3,500 ft^3/sec. The 100-yr flood is 4,100 ft^3/sec, the 200-yr flood is 4,800 ft^3/sec, and the 300-yr flood is 5,300 ft^3/sec.

Several synthetic floods with a recurrence interval of once in 300 yr were routed. Several methods were considered as flood control improvements. If the INEL diversion channel were widened along with other improvements, the diversion system could control a 300-yr flood. At present, the INEL diversion system can control a 55-yr flood. A study is presently being conducted by the USGS on rare and catastrophic floods and the effects of these floods on INEL facilties. Results of this later study will not be available until the summer of 1977.

Two major artificial controls affect the river in addition to irrigation diversions. These are Mackay Dam and the INEL flood diversion system in the southwestern part of the INEL (Figure II-64). The INEL flood-control diversion system was constructed in 1958 to reduce the threat of floods on the INEL from the Big Lost River. The diversion dam can divert flow out of the main channel to spreading areas A, B, C, and D. During winter months, nearly all flow is diverted to avoid accumulation of ice in the main channel downstream on the INEL. Also during periods of high discharge, much of the flow is diverted automatically to the spreading areas. Details of the channel regimen and hydraulics of the river on the INEL also are discussed in a previous report[72].

All flow of the Big Lost River that enters onto the Snake River Plain is recharged to the subsurface, except for evaporation losses. Recharge effects from the Big Lost River are very pronounced in the Snake River Plain aquifer and in perched water beneath the river.

b. Subsurface Water

Groundwater that serves as the sole INEL water supply source is the most important factor of INEL hydrology. Although the Snake River Plain aquifer is the principal groundwater body, in some areas of the plain, including INEL, local bodies of perched groundwater also may be important. Only a summarized description of the groundwater resources at INEL is presented here; more comprehensive information can be found in published reports[73,74,75,76].

(1) Snake River Plain Aquifer

The Snake River Plain aquifer is a continuous body of groundwater underlying nearly all of the eastern Snake River Plain.

The aquifer is about 200 miles long by 30 to 60 miles wide, and comprises an area of about 9,600 square miles. Lithologically, the aquifer is composed of a series of thin basalt flows, generally 10 to 75 ft thick, interbedded with layers of fluvial, lacustrine, windblown, and pyroclastic sediments. Most of the aquifer permeability occurs along the upper and lower contacts of successive basaltic flows. These flows have large and irregular fractures, fissures, and other voids. This leads to a large degree of heterogeneity and anisotropy in the hydraulic properties of the aquifer.

The thickness of the aquifer is not known because no wells have been drilled deep enough to pass through it. The deepest well is only 1,300 ft. Most evidence indicates that the aquifer is between 1,000 and 5,000 ft thick in the INEL region. The effective thickness of the aquifer may be on the order of only 1,000 ft and it may contain 2,000 million acre-feet of water, of which 500 million acre-feet might be recoverable[75]. Even though the basalt-sediment sequence which fills the Snake River Plain depression may be 5,000 ft or more thick, the upper part of the sequence, perhaps the upper 500 ft, may be considerably more permeable and thus the most effective part of the aquifer.

Groundwater generally flows southwestward through the aquifer from the north and northeastern recharge areas to the south and southwestern discharge areas. About 6.5 million acre-feet (2.12×10^{12} gallons) are discharged by the aquifer annually[74]. Most of the discharge occurs as springs near the Hagerman area and a region west of Pocatello, and as irrigation well withdrawals. The water table in the Snake River Plain aquifer slopes from northeast to southwest at an average gradient of about 10 ft/mile. The depth to the water table ranges from zero in some of the spring discharge areas to about 1,000 ft below the surface a few miles southwest of the INEL.

Average flow rates in the aquifer are difficult to assess. Tracer studies at the INEL indicate natural flow rates in the range of 5 to 20 ft/day with an average near 10 ft/day. However, these local measurements are not necessarily representative of velocities throughout the aquifer.

(2) Snake River Plain Aquifer at the INEL

The part of the Snake River Plain aquifer beneath the INEL is typical of the aquifer in general. Depth to the regional water table (Snake River Plain aquifer) at the INEL varies from about 200 ft in the northeast corner to 900 ft in the southwest corner. Depth to water in the TRA-ICPP area is about 450 ft. The average hydraulic gradient is about 5 ft/mile to the southwest (Figure II-66). Data indicate that about 2,000 ft^3/sec flow beneath the INEL at its widest point[73].

Figure II-66 is a map of the INEL and adjacent areas showing contours on the Snake River Plain aquifer for July 1972 and inferred directions of the groundwater movement. The altitude of the water

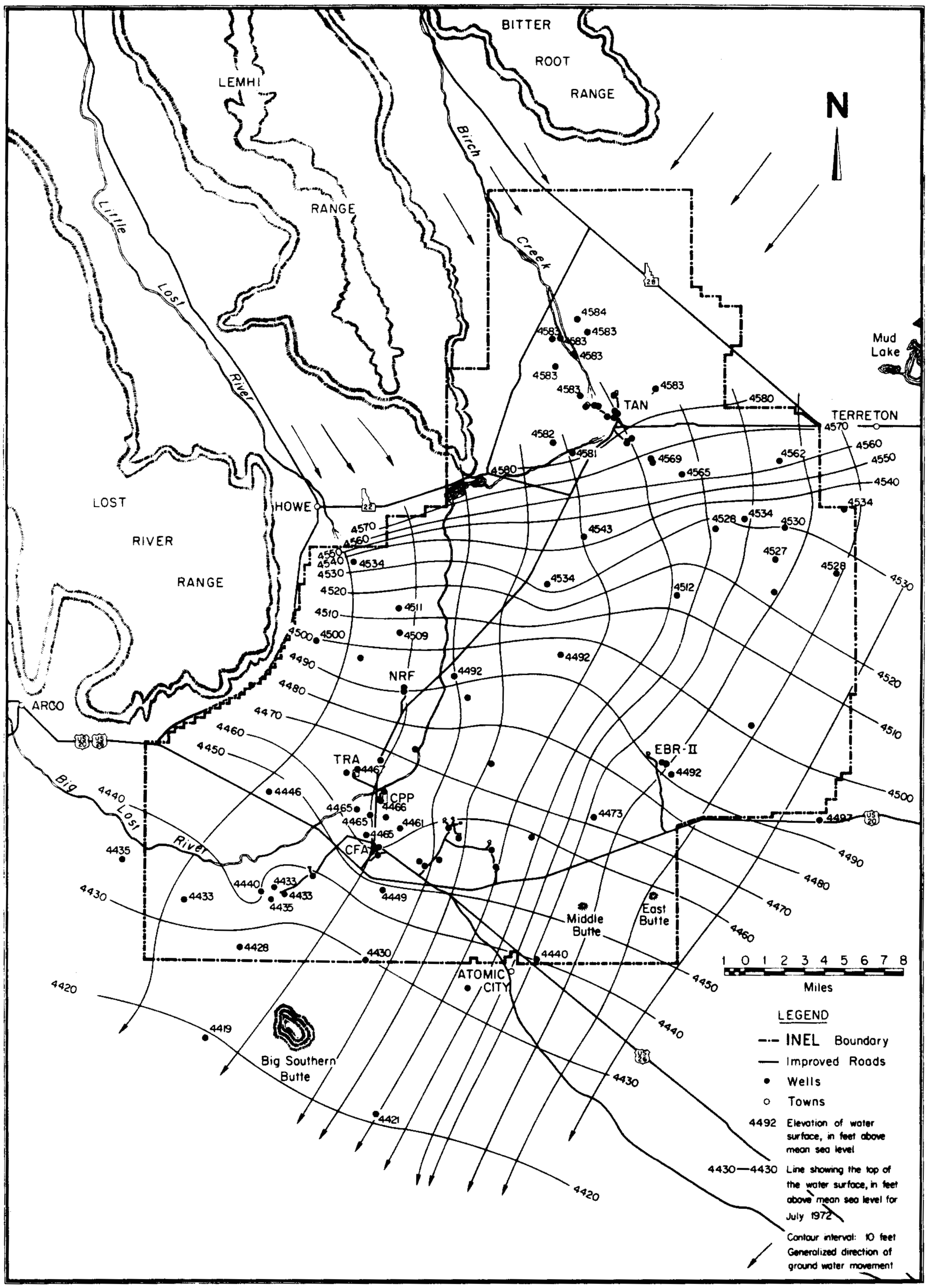


Figure II-66. INEL Subsurface Waterflows.

table ranges from 4,584 ft at Test Area North to 4,419 ft above mean sea level near the southwestern boundary of the site. The general direction of regional groundwater movement underlying the INEL is to the south and southwest. In the northern part of the INEL, near the Birch Creek valley, the water table gradient is relatively flat. It slopes southward about 4 ft in 7 miles. This flat gradient is a result of relatively greater aquifer permeability or thickness than in the Birch Creek valley. Although a significant amount of underflow enters the area, the head required to transport the water is slight.

In 1974, the entire INEL water supply was provided by 24 production wells which tapped the Snake River Plain aquifer. The wells pumped a total of 2.9×10^9 gallons for the year. About half of the volume pumped is returned to the subsurface by waste disposal operations. An additional unknown amount also returns underground by infiltration from lawn irrigation and other water uses. A significant amount (nearly half) of the pumped water is consumed by evaporation and transpiration to the atmosphere, principally from reactor cooling towers and lawn irrigation. The calculated underflow of 2,000 ft^3/sec beneath the INEL is equivalent to 4.7×10^{11} gallons/yr. Therefore, if INEL operations consume 1.3×10^9 gallons/yr, the consumption is less than 1% of the INEL underflow and less than 0.1% of the total annual aquifer discharge.

The most significant natural recharge to the aquifer within the INEL is from the Big Lost River. A small amount of recharge occurs from infiltration of precipitation directly on the INEL and in some years of high runoff, Birch Creek water flows onto the INEL and seeps underground. The Big Lost River drains into a closed basin terminating at the northern end of the INEL. Therefore, all Big Lost River water entering the INEL is recharged to the Snake River Plain aquifer (minus evaporation losses).

(3) Well Hydrographs

Hydrographs of the wells penetrating the Snake River Plain aquifer have different characteristics from place to place, but all reflect natural recharge variations as well as pumping and irrigation influences.

Groundwater hydrographs from the northern part of the INEL reflect groundwater recharge from Birch Creek, other streams to the north, and underflow from the area to the northeast. The annual precipitation at the TAN has ranged from 4.4 in. in 1956 to 15.6 in. in 1963 and averaged about 8.2 in. The differences in precipitation at the TAN appear to have little effect on the groundwater levels in nearby wells. The discharge of Birch Creek near Reno, Idaho is remarkably constant for the period of record. Average annual flow ranged from 75.2 to 84.2 ft^3/sec and the 15-yr average is 78.8 ft^3/sec (57,000 acre-feet/yr). Birch Creek is fed by uniform flowing springs which are annually recharged by snowmelt. Apparently little overland flow from snowmelt is carried across the long alluvial fans into Birch Creek.

The hydrographs indicate that the Snake River Plain aquifer water level in the northern part of INEL remains rather constant over the period of record. The recharge effects from precipitation are generally dampened and represent a rather uniform volume of groundwater flow entering the INEL from the north and northeast.

Hydrographs of wells in the eastern part of the INEL show response to recharge from Mud Lake and from the northeastern part of the Snake River Plain. Water levels in the wells have a normal cyclic fluctuation of 2 to 5 ft annually. These annual changes probably represent the influence of the spring runoff due to snowmelt and recharge from irrigation. Water levels start to rise in late summer, peak in the winter, and then decline until the next rise in the summer.

Hydrographs of wells in the central part of the INEL show rising water levels during periods of flow in the nearby Big Lost River and declining water levels during years of no flow. The maximum water level change over the period of record has been about 7 ft. The high occurred in 1973 and the low in 1964.

Hydrographs of wells in the western part of the INEL reflect recharge effects from the Big and Little Lost Rivers. High water levels were measured in 1953-54, 1959, and 1966-72; the lowest water levels occurred in 1964. Water levels in this part of the INEL fluctuate more than those in any other part of the station, apparently because of hydraulic boundary conditions and recharge effects. Water levels in wells at the western part of the INEL have fluctuated almost 22 ft during the period of record, the maximum change measured at the INEL from 1950 to 1973.

The hydrographs of wells in the southeastern corner of the INEL reflect recharge from the Mud Lake area and from areas farther northeast on the Snake River Plain. In addition, these hydrographs also reflect recharge from the Big Lost River. The highest water levels occurred during the period of 1950 to 1953, and the lowest in 1964. The water levels show fluctuations of 4 to 6 ft over the period of record and usually show an annual cyclic change of 1 or 2 ft. Water levels generally have declined about 2 ft during the period of record.

Hydrographs of wells near the southwest corner of the INEL are strongly affected by major flows in the Big Lost River. The water levels declined from 1951 to 1964, until recharge from the Big Lost River in 1965 to 1972 caused some rapid increases. Water levels have fluctuated about 5 to 8 ft during the period of record. Long term hydrographs of wells show annual cyclic fluctuations with peaks occurring from November to January each year. Water levels in wells in this area have declined about 2 ft during the period of record.

(4) Perched Groundwater

When the Big Lost River flows on the INEL, water infiltrates the channel bottom and percolates downward toward the aquifer. Layers of fine-grained sediments with low permeability tend to retard the downward percolation, forming perched groundwater beneath the river. Perched water undoubtedly occurs beneath other parts of the Big Lost River system where there are high seepage losses, such as the INEL diversion area. However, there are very few wells available for monitoring such perched water.

The most significant body of perched water resulting from waste disposal occurs at the TRA, beneath the waste seepage ponds[75a].

(5) Perched Water at the TRA

Infiltration from the TRA ponds has formed at least two major perched water bodies beneath the TRA (Figures II-67 and -68). One is perched on the basalt layer located about 50 ft below the surface. A second, and much larger, perched water body occurs on a layer of clay and silt within the basalt about 150 ft below the surface and about 300 ft above the regional water table. Lower sediment layers within the basalt retard the water as it moves downward to the Snake River Plain aquifer and probably cause additional perched-water bodies.

(6) Perched Water in the Alluvium

The perched water in the alluvium near the radioactive waste disposal ponds covers an area of about six acres. The perched water body varies in size with variations of the average discharge rate to the ponds. Generally, the perched groundwater in the alluvium covers an area about twice the size of the pond area.

The perched body of water in the alluvium around the chemical waste disposal pond covers an area of about four acres. This water seeps generally downward into the basalt to form another perched body which tends to prevent perched radioactive waste water from moving northward toward the TRA supply wells. The body of perched chemical waste water generally has remained about the same size for the past 10 years.

(7) Perched Water in the Basalt

The large perched water body within the basalt at the TRA covers an area of about 325 acres (6,000 by 3,000 ft) and saturates a maximum thickness of 100 ft between the depths of 60 and 160 ft below the surface (Figure II-67). The water table slopes laterally outward below the ponds in every direction and at a gradient of from 150 to 200 ft/mile. The perched water body in the basalt is composed of seepage water from all the ponds in the TRA. The chemical content of the water indicates from which ponds the water is derived. Water from the chemical disposal pond is high in specific conductance and chloride while waste water from the radioactive disposal pond contains tritium.

The general shape of the perched water body has not changed much in the past 14 yr. However, the perched water levels in

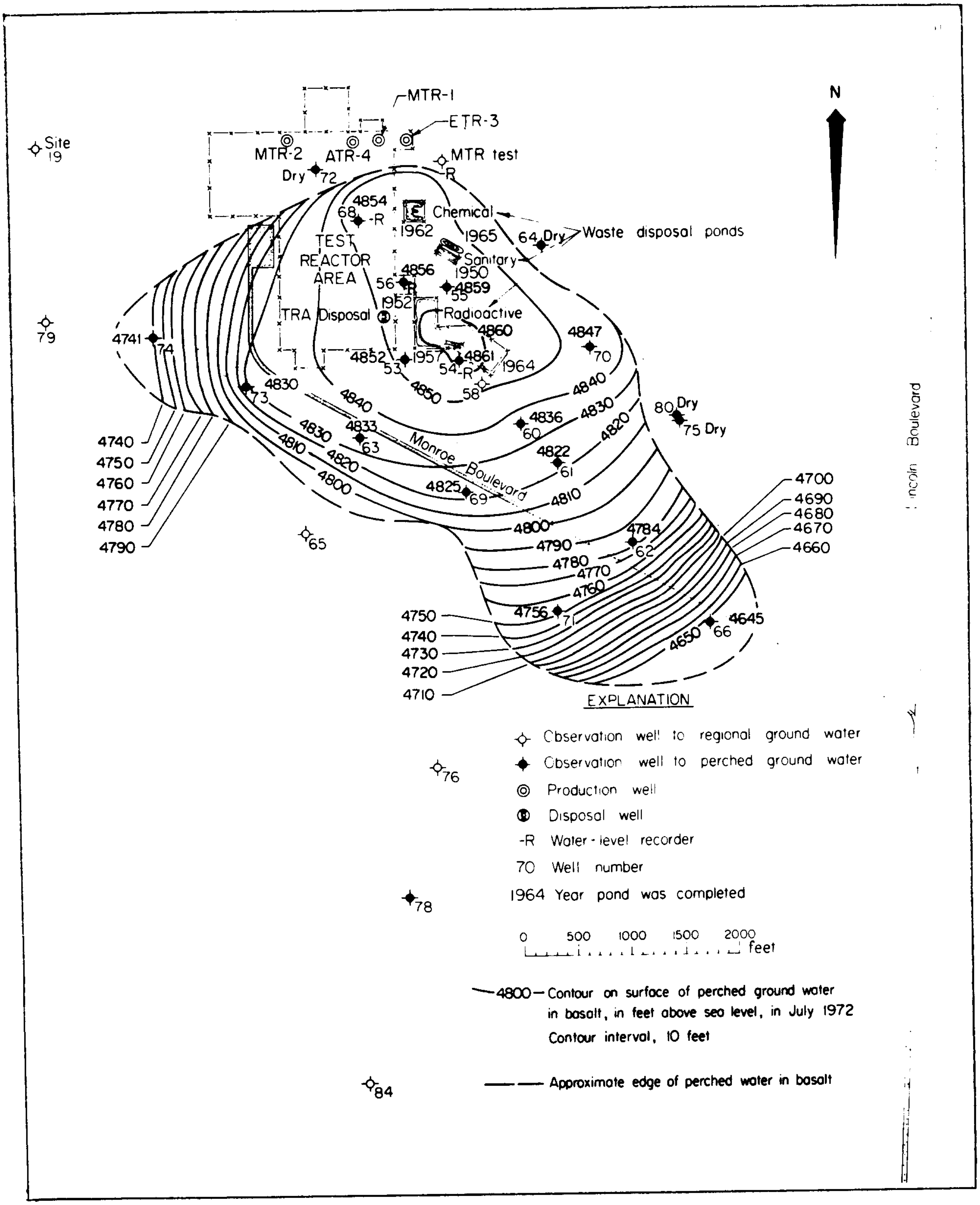


Figure II-67. Map of the TRA Showing Water-Level Contours on the Surface of the Perched Groundwater in the Basalt on July 1972.

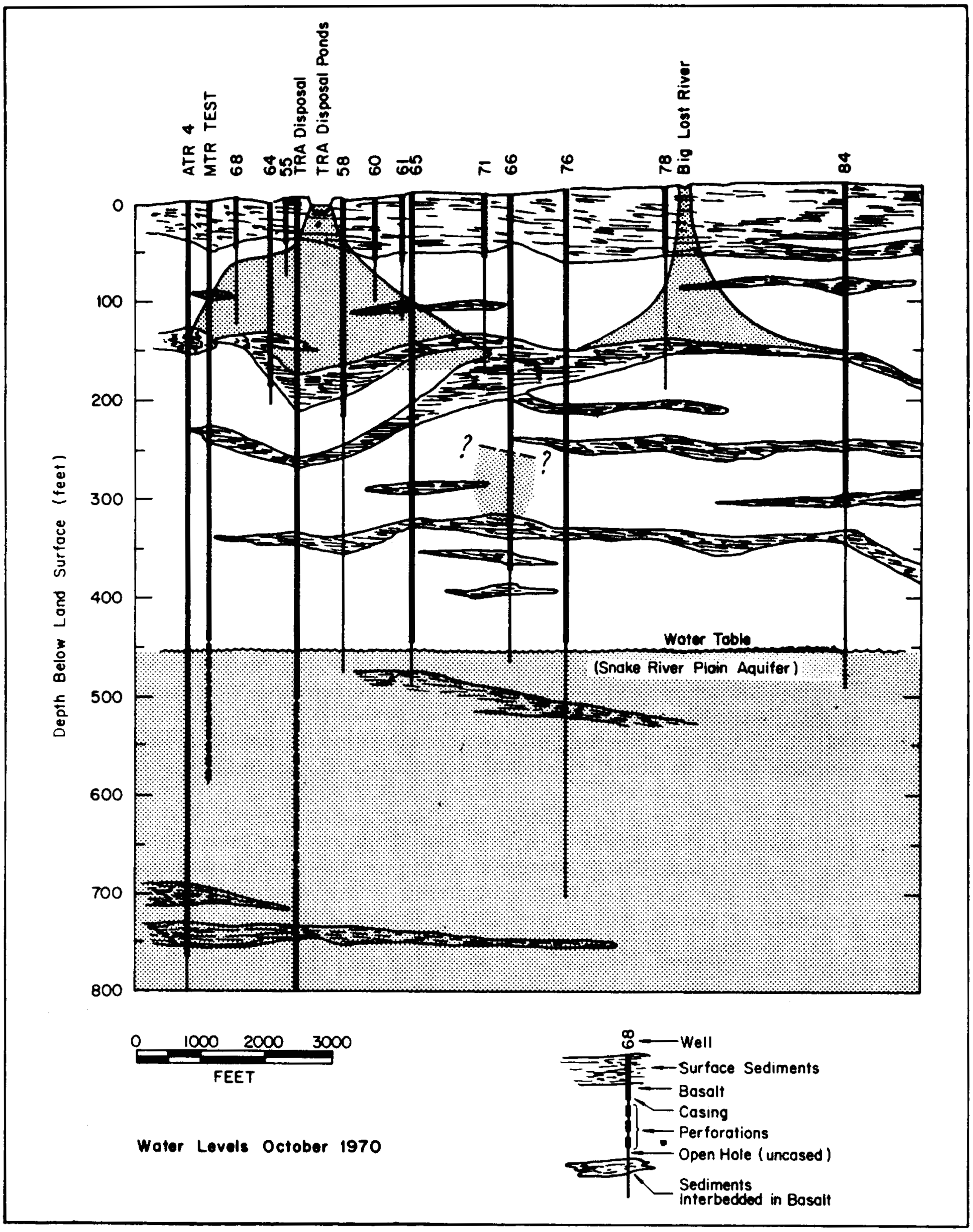


Figure II-68. Geologic Cross Section at the TRA Showing the Bodies of Perched Water and the Snake River Plain aquifer.

individual wells have fluctuated over a wide range. The fluctuations respond to variations in the pond discharge. Approximately the same volume of liquid waste as is being disposed of daily is percolating downward through the perching beds and then downward through the unsaturated zone to the Snake River Plain aquifer.

Infiltration from the Big Lost River has created a perched water body in the basalt near the TRA which has an influence on the TRA perched waste water. Flow in the river induces groundwater recharge, which in turn causes water level rises in the TRA perched water table. The data on these water-level responses from a known source of water are useful to compare with nearby movement of waste water through the perching beds. Water level in a well 235 ft from the river shows a rapid response to initial flow in the river. The water level starts an abrupt rise within about 4.5 days after water first flows in the Big Lost channel. The water moves 170 ft downward and 235 ft laterally in about 4.5 days, or about 80 to 90 ft/day. This value is reasonable based on the high permeability of the rocks and the steep hydraulic gradient.

(8) Fluctuations of the Perched Water Levels

The TRA perched water table in the basalt fluctuates according to the fluctuation in volume discharge to the ponds. Data show that from 1960 to the summer of 1964, the perched water level rose as the discharge increased and declined as the discharge decreased. Since then, some of the waste water uncontaminated with radionuclides has been diverted to a separate pond and to a disposal well, altering the relationship somewhat. The perched water level began a general decline in June 1962 which lasted until July 1966. The water level started a general rise in 1966 which has continued through 1974.

The regional water table (Snake River Plain aquifer) at the TRA rises during years of high runoff and declines during years of low runoff in the Big and Little Lost Rivers, and has little apparent relationship to the perched water fluctuations. The regional water table has fluctuated about 11 ft during the 24 yr of record. The water level is now about as high as it was in 1952.

(9) Quality of Groundwater at INEL

The chemical quality of groundwater at the INEL reflects the different sources of recharge and the minerals dissolved from rocks in the Snake River Plain aquifer. The geochemical properties of the water determine its suitability for various uses and are used to evaluate the changes in groundwater quality caused by INEL operations. Detailed studies of the geochemistry of the Snake River Plain aquifer at the INEL are available[76,76a,76b].

The amount of dissolved solids in groundwater indicates the mineralization of the water. The concentration of dissolved solids in groundwater at the INEL, not affected by INEL waste disposal, ranges from 144 to 542 mg/ℓ. Most of the groundwater at INEL has dissolved solids of from 180 to 225 mg/ℓ. Groundwater in the southeast corner of INEL has the lowest dissolved solids (less than 200 mg/ℓ) because of the more dilute water from the northeast. A few other wells have a dissolved solids content of less than 200 mg/ℓ. The highest dissolved solids content is in the northeastern part of the INEL near Mud Lake. High values of dissolved solids southwest of Mud Lake probably reflect the concentration of constituents by evaporation during irrigation. These high values are attenuated rapidly down gradient by the nearby dilute water. The dissolved solids content in groundwater at the INEL is low enough that the water is suitable for drinking, irrigation, and most industrial uses, but too high for use in boilers and in some cooling systems.

The water temperatures in groundwater at the INEL range from 48 to 62°F and usually average about 55°F. The warmest water occurs near Mud Lake and near Howe, and indicates recharged irrigation water heated by the sun. The coolest water occurs south of Birch Creek and also in parts of the Big Lost River. The temperature of the groundwater at the INEL increases with depth. The geothermal gradient at INEL increases in temperature almost 1°F for each 100 ft of additional depth.

The prewaste disposal sodium content of groundwater at the INEL ranges from 6 to 42 mg/ℓ. The sodium content of the groundwater in the west half of the INEL is generally less than 10 mg/ℓ. The sodium content of water in the east half of the INEL is generally between 10 to 20 mg/ℓ. The highest sodium value occurs to the south of Mud Lake and is attributed to concentration by evaporation of irrigation water. The amount of sodium in the groundwater at the INEL is low enough so that the water would be suitable for almost any use.

Most of the sodium in waters at the INEL is fully balanced by chloride, indicating that sodium chloride is the source of the values. The chloride content of the groundwater at the INEL ranges from 6 to 160 mg/ℓ. The chloride content of much of the groundwater at the INEL is between 7 and 20 mg/ℓ. The chloride content is highest in the area south of Mud Lake. The unusual composition of this body of chloride rich water has been described in detail[76]. Two other areas contain groundwater with a higher chloride content than the chloride content of the surrounding water. Both of these areas are in the southwest part of the INEL. The possible explanations for these areas include irrigation recharge, waste disposal, and thermal water. With few exceptions, the chloride content of the groundwater within most of the INEL is sufficiently low so that the water is suitable for most uses. Normally, water containing a chloride content of less than 50 mg/ℓ is acceptable for most industrial water uses; a chloride content of less than 100 mg/ℓ is acceptable for most irrigation requirements; and a chloride content of less than 250 mg/ℓ is acceptable for a domestic water supply.

The pattern of sulfate distribution in groundwater at the INEL shows a decrease from about 25 mg/ℓ on the northwest to about 10 mg/ℓ on the southeast. Surface water analyses indicate that the predominant source of sulfate is to the north (Medicine Lodge Creek). Dilution of sulfate to values below 10 mg/ℓ in the southeastern part of the INEL provides good evidence for identifying the recharge to this area. Recharge with Snake River water which contains about 60 mg/ℓ sulfate is impossible. Instead, low sulfate water from the northeast satisfies the sulfate dilution requirement. The highest sulfate values were found in the area south of Mud Lake. High values near the center of the INEL correlated with high values of bicarbonate, chloride, and calcium and appear to be related to disposal of waste.

The composition of groundwater at the INEL can be affected in a limited way by the phenomenon of cation sorption. Minerals capable of sorbing cations within their structure (such as some clay minerals, fine-grained minerals, and amorphous solids capable of sorbing cations at broken bonds on their surfaces, edges, and corners) tend to exchange and equilibrate with cations in the surrounding solution. In natural groundwater systems, changes in water composition tend to be slight and extend over such long periods that exchangeable cations on solids always approach equilibrium with the surrounding solution. Only relatively large changes in water composition of extended duration will produce major changes in the ratio of cations held by exchange.

Recharge of recycled irrigation water containing sodium in a greater ratio to the other cations than exists in the groundwater tends to remove exchangeable calcium, magnesium, and potassium from the rock or soil and replace them with equivalent amounts of sodium. When sufficient sodium has been removed from the percolating water to restore the original cation ratios, the process of removing sodium will stop. While sodium is being removed from solution, the other cations are displaced into solution, thus tending to create a new solution with cation ratios closer to the original groundwater. If the groundwater moves rapidly, dispersal of recharged irrigation water into the groundwater will tend to make compositional differences less apparent.

Groundwater in the Snake River Plain is very dilute and is satisfactory for most purposes without treatment. The low dissolved solids content reflects the abundant rain and snowfall in the surrounding mountains. The composition of the groundwater indicates reaction with minerals in rocks of the surrounding mountains and alluvial valleys where residence time of the groundwater is relatively long. Groundwater compositions do not show detectable effects of reaction with Snake River Plain rocks in which water movement is rapid. High evaporation rates on the arid plain increase the dissolved solids in water used for irrigation, but recharged irrigation water loses its identity quickly in groundwater due to rapid dilution and dispersion.

10. Bioenvironment

The vegetation of the INEL is limited by the type of soil, meager rainfall, and extended drouth periods to mainly sagebrush, perennial herbs, and a variety of grasses. Extensive surveys of INEL vegetation were carried out in 1952, 1958, and 1967, utilizing 150 permanent transects established and maintained for this purpose[77]. The results of this work were used to prepare a map of INEL vegetation types (Figure II-69). The INEL has only a few trees, located principally along the Big Lost River. The most prominent ground cover is a mixture of vegetation consisting of sagebrush (Artemesia tridentata), lanceleaf rabbitbrush (Crysothamnus viscidiflorus), and a variety of grasses. Approximately 80% of the station exhibits this type of ground cover.

Other types of vegetation found on the INEL are as follows:

(a) Grasses: Agropyron spicatum, Hordeum jubatum, Sitanioon hystrix, Oryzopsis hymenoides (Indian ricegrass), Stipa comata, Poa secunda, Elymus canadensis (Canada wild rye); Agropyran smithii (bluestem wheatgrass), Agropyron cristatum (crested wheatgrass)

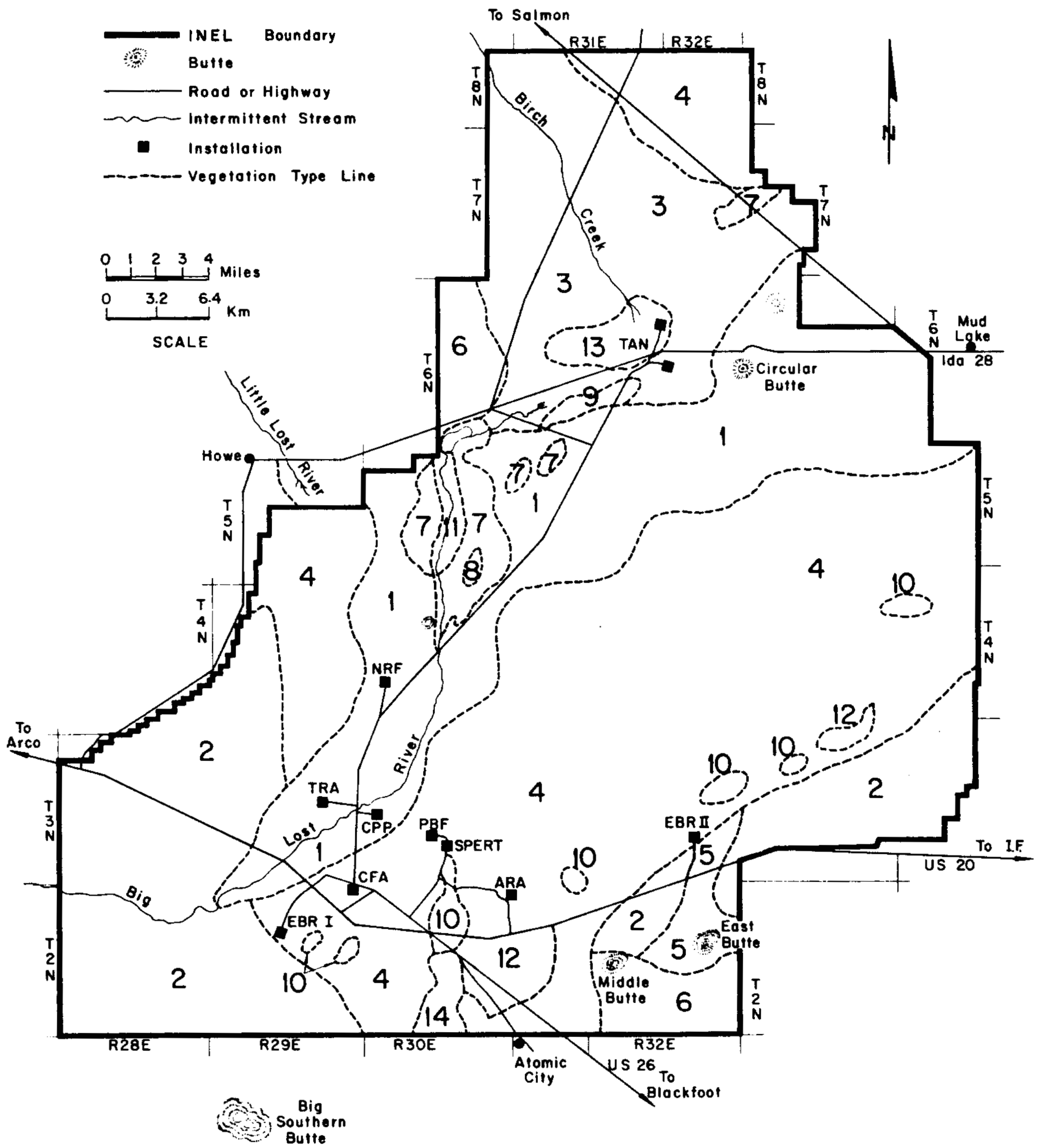
(b) Shrubs: Atriplex confertifolia (shadscale), Chrysothamnus nauseosus (rubber rabbitbrush), Gutierrezia sarothrae (matchbush), Chamabatiaria millefolium (fernbush), Tetradymia spinosa, Atriplex nuttallii (Nuttall's saltbush), Eurotia lamata (winterfat)

(c) Trees: Juniperus utahensis (juniper), Populus angustifolia (cottonwood), Salix sp. (willow)

(d) Other: Opuntia polyacantha (prickly pear cactus), Rosa sp. (rose), Iva axillaris.

The vegetation of the INEL supports a variety of wildlife consisting mainly of small mammals, birds, reptiles, and a few large mammals. The small mammals include chipmunks, ground squirrels, several species of mice, kangaroo rats, and jackrabbits. The pronghorn antelope inhabits the INEL during the entire year; however, many of the antelope are migratory and winter south of the INEL and summer to the north of it. Antelope occasionally fawn on the station in the spring as they move northward into the Birch Creek valley. Coyotes and bobcats are seen frequently. Sage grouse and pheasants are the only resident game birds on the INEL; however, hunting is not permitted. In addition to raptors and other indigenous and introduced species of birds, some migrant species pass through the areas. These include doves, larks, hawks, ducks, geese, and golden and bald eagles. The only endangered species occasionally frequenting the station is the peregrine falcon. The reptiles consist mainly of lizards and a few snakes. Domestic sheep and cattle are allowed to graze on the perimeter areas of the station in the early spring and fall. Large mammals are excluded from the immediate facility areas by security fences.

Aquatic life on the INEL is limited and is mainly dependent upon the flow of the Big Lost River. The riverbed is quite permeable, and during several months of the year, the river does not sustain flow conditions. However, during spring runoff and high rainfall



1	Artemisia tridentata/Agropyron dasystachyum
2	Artemisia tridentata/Agropyron spicatum
3	Artemisia tridentata/Eurotia lanata
4	Artemisia tridentata/Sitanion hystrix
5	Artemisia tripartita/Agropyron spicatum
6	Juniperus osteosperma/Agropyron spicatum
7	Eurotia lanata-Atriplex falcata
8	Atriplex falcata
9	Eurotia lanata
10	Elymus cinereus
11	Agropyron smithii
12	Agropyron desertorum
13	Playas
14	Recent lava flows

NOTE:

Adapted from "Vegetation Patterns of the National Reactor Testing Station, Southeastern Idaho" by Roy O. Harniss and Neil E. West, Department of Range Science, Utah State University.

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Figure II-69. Distribution of Vegetation at the INEL.

conditions the diversion system (southern boundary of the station) and the Big Lost River Sinks (northern area of the station) support waterfowl during periods of water accumulation. This normally occurs less than two or three months in the spring but, depending on annual conditions, water flow and accumulation may be sustained for several months. The small liquid waste disposal ponds at the TRA and NRF are also a habitat for a small number of water-seeking animal life. The above waters attract various species of ducks, Great Blue Heron, and a variety of smaller shore birds. The HSL, in cooperation with local universities, is presently investigating the animal life associated with these waters.

11. Programmatic and Accidental Releases

The large land area, the absence of surface drainage from the area, and low population densities in the proximity of the INEL provided a location that has enabled scientists and engineers to carry on nuclear experiments with minimal impact upon the general population. Since the establishment of the INEL, 51 reactors, a chemical processing plant, and related support facilities have been constructed. The chemical processing plant and 17 of the reactors are still operable.

In conjunction with the construction of the nuclear facilities such programs as the Aircraft Nuclear Propulsion (ANP), Special Power Excursion Reactor Tests (SPERT), and Systems for Nuclear Auxiliary Power (SNAP) were established at the INEL. The testing associated with these and other programs occasionally calls for planned and monitored radioactive releases to the atmosphere. During the operation of the nuclear facilities at the INEL in the last 22 yr, there also have been a few accidents that have resulted in radioactive releases to the environment. A chronological summary of the significant programmatic and accidental releases that have had impact on the waste handling practices or have resulted in residual waste management programs at the INEL, and which characterize the development of the existing site environment is given below. Other programmatic or accidental releases of less consequence are briefly described in Appendix C.

a. Aircraft Nuclear Propulsion Program (ANP)

The ANP project[78] was initiated in the early 1950s to develop a nuclear powered jet engine for military aircraft. Testing of the nuclear engine concept was to be carried out at a remote site to reduce the consequences to the general public and private property in the event of a nuclear accident. Testing of the reactor jet engine systems was accomplished at the TAN.

The ANP reactors were direct, open-cycle, air-cooled; this means that air was drawn into the jet engine, compressed, passed through the reactor fuel element where heat energy was extracted, and then discharged through the turbine and jet engine nozzle. Any radioactivity leaking from the fuel elements was also discharged to the airstreams.

The test facility was equipped with ductwork to direct the air from the jet engine nozzles to a 150-ft-high stack so that any evolution of radioactive material in the jet engine exhaust was released to the atmosphere at that point.

Techniques for operating the reactor based on existing weather conditions and the resulting calculated downwind doses to offsite population were soon developed in the program.

Stack monitoring and the monitoring of effluents at downwind locations were performed using state-of-the-art techniques available at the time initial tests started in 1955; at that time, highly sophisticated methods and techniques had not been developed. Nevertheless, data were adequate to show that even though measurable quantities of radioactivity were detected at offsite locations, the dose to people was below the exposure guidelines current at that time[79-83]. The contribution of ANP tests to the measured population dose was often masked by the effects of the Soviet and United States aboveground weapons tests which spanned the same time period.

In addition to the releases discussed above, which were considered to be normal test releases, several tests were conducted which involved deliberate fuel element failure by blocking the coolant passages to a test fuel element in an effort to determine, on a small scale, what would happen in a full scale aircraft reactor accident[84]. These tests were conducted under carefully selected meteorological conditions to ensure that downwind population would not receive radiation exposures above established limits. An extensive network of onsite and offsite sampling stations was established for these tests, not only to obtain field data on the releases but to ensure that the radiation doses were assessed accurately. The principal contributor to doses from these tests was radioactive iodine. Since this was the controlling radioactive element from the population dose standpoint, a milk sampling program was established in surrounding communities for these tests.

There was also one accidental release of radioactivity to the atmosphere which resulted from equipment malfunction[85]. The accident caused a significant portion of a reactor core to melt and expel fission products to the atmosphere. The cloud from the atmospheric release remained almost entirely onsite and, although the cloud path could be traced by postaccident monitoring for several miles across the INEL, no detectable activity was found offsite. Since the majority of the released radioactivity was of short half-life, no evidence of radiation could be found in environmental samples a few weeks after the release.

An estimated 50,000 Ci of total activity were released to the atmosphere during the ANP testing program.

Radioactive liquids were generated mostly through cleanup work in the hot shop and hot cells (shielded cells where the reactor core was disassembled and inspected). These cells were plumbed with drains to three 10,000-gallon radioactive liquid storage tanks. Liquid from the tanks was processed by distillation. The distillate was collected and sampled before discharge to a disposal well. The condensed radioactive residue was stored in one of two 50,000-gallon storage tanks at the TSF. This waste is being processed through the TSF evaporator system which is described in Section II.A.4.c.

b. The RaLa Process Operations at the ICPP

From February 1957 to April 1963, spent fuel elements were processed at ICPP to recover the fission product barium-140 and the residual uranium-235. When barium-140 undergoes radioactive decay, a radioactive isotope of lanthanum (RaLa) results. When the lanthanum-140 isotope decays, it emits a high energy gamma ray which was desired for a special need. Although the ICPP process resulted in recovering kilocurie quantities of barium-140, it took the name from the desired end product.

Usually the fuel reprocessing at the ICPP is performed only after the fuel has been out of the reactor for at least 120 days, allowing for significant decay of the gaseous fission products. Since barium-140 has a radioactive half-life of only 12.8 days, the fuel was processed as soon as possible after being removed from the reactor (normally about 36 hr). This resulted in inordinate releases of airborne radioactive wastes. During the earlier runs, these products were released to the stack. Later improvements made in the system and in operating procedures resulted in declining release quantities.

Iodine-131 was the nuclide of paramount radiological hazard and was a matter of concern. The estimated amount released is shown in Table II-60. The equipment was designed originally to contain and control the iodine. All vessels were kept under a partial vacuum, and off-gas streams were routed through a scrubber before being exhausted to the stack. The efficiency of this scrubber was low, however, so further improvements were necessary to limit undesirable releases. One improvement was the installation of a 10,000 ft^3 holding tank which provided time for radioactive decay. Another improvement was the modification of the shaft seals to withstand pressurization of a centrifuge at systems leading to this stack. These and other operational changes resulted in reductions in the amount released as shown in Table II-60.

During the time of the RaLa operations, the environmental monitoring program was expanded to assess the impact from the released radionuclides[79-83]. The nuclide of major concern (iodine-131) has a half-life of 8 days and has long since decayed to innocuous levels. No residual contamination can be attributed to this program. Reactivation of this program is not projected.

TABLE II-60

ESTIMATED AMOUNTS OF IODINE-131 RELEASED
DURING RALA PROCESS RUNS AT ICPP

Year	Process Runs	Iodine-131 Released (Ci)
1957	5	863
1957	3	540
1958	13	1,028
1959	16	227
1960	12	32
1961	17	42
1962	9	40
1963	4	25
		2,800

c. The ICPP Criticality Incident

At approximately 0250 hours on October 16, 1959, a nuclear criticality incident occurred in a process equipment waste collection tank at the ICPP. Available evidence[86] indicated that the critical condition resulted from the accidental transfer of a concentrated uranium-nitric acid solution from geometrically safe storage containers in a process cell into a waste collection tank through a line normally used to transfer decontaminating solutions to waste. Siphon action, initiated by air-mixing the uranium-nitric acid solution prior to sampling, was the most likely mechanism by which the transfer took place.

The main radioactivity release to the environment from this incident was in the form of a gaseous "cloud" released from the ICPP stack. Gaseous activity released was calculated assuming that all the noble gases, 25% of the halogens[87], and no solid fission products generated in the criticality were released. A 30-sec critical period was assumed along with a 3-min delay time for the fission products to be exhausted from the ICPP stack. Total activity released to the atmosphere was $\sim 3.5 \times 10^5$ Ci, of which only 200 Ci remained after 1 day; 4 months after the incident the levels had decayed to less than 1 Ci.

Winds of 10 to 16 mph dispersed the atmospheric release from the ICPP in the general direction of the CFA. No residual contamination can be identified at the INEL as a result of this accident.

While in the process of returning the large volume of solution generated in recovery operations from underground storage tanks to the process system through an improvised line, a flange gasket failed and spilled an unknown quantity of the dilute solution on the ground. All contaminated soil, as indicated by radiation measurements, in the vicinity of the leak was collected and placed in two metal boxes and sent to the Radioactive Waste Management Complex.

d. The Stationary Low Power Reactor No. 1 (SL-1)

The SL-1 reactor became operational in 1958 and was housed in a cylindrical steel structure, which was filled with concrete around the reactor pressure vessel for shielding. A successful 500-hr full power performance test was completed in December 1958. Operation of the plant at 3 MW continued for slightly more than 2 yr. In December 1960, the reactor was shut down for routine maintenance, some minor modifications, and the installation of some neutron flux monitoring devices in the form of wires in the core. This work involved moving the shielding blocks from the top of the reactor and removing selected control rod drive mechanisms (CRDMs).

During the evening shift on January 3, 1961, a three man military crew apparently was reinstalling the CRDMs, which required lifting the control rods a very short distance to make the connection. It is presumed that while connecting the central control rod, it was lifted far beyond the distance required for connection. A reactor power excursion ensued which resulted in the deaths of the three operators and gross damage to the reactor[88,89]. Radioactivity (mainly fission products from the badly damaged fuel elements) was released into the reactor room so that initial attempts to rescue the personnel resulted in exposure to rescue crews to dose rates in the 1,000-R/hr range. Although the SL-1 reactor building was not designed to be leaktight, it contained the radioactive release from the reactor very well. It should be noted that although the reactor itself was severely damaged, damage to the building was only minor.

Extensive surveys were made in the weeks following the accident[90]. Using known meterological information and data from samples downwind from the SL-1, it was estimated that approximately 10 Ci of iodine-131 were released during the first 16 hr after the accident and about 70 Ci were released over the following 30-day period. The samples showed that the radiological dose from iodine-131 was by far the controlling dose factor but that the dose to the population downwind was negligible.

The cleanup operations from this accident extended over the next year and resulted in the opening of a local waste burial ground described in Section II.A.9. The cleanup of SL-1 included removal of the reactor pressure vessel, which contained the fueled core, and transportation of the vessel in a large shielded cask to the TAN, where it was dismantled in the hot shop. The silo-like reactor building was dismantled and buried along with all of the equipment it contained. The remaining buildings and ground in the complex were decontaminated and are now in use for other INEL activities[91].

e. The SPERT-I Destructive Test Program

Recognizing the need to understand the physical phenomena and hazard involved in reactor excursions, the SPERT program tests were undertaken in 1954. Experiments at the inception of the SPERT program included not only basic nondestructive studies of the importance of various parameters in reactor kinetic behavior, but also planned integral core destructive tests to investigate the consequences of reactor accidents.

Prior to initiating the series of tests and particularly before conducting the actual destructive tests, an intensive safety evaluation was performed to identify all potential hazards and to ensure that the necessary safeguards were provided to preclude any unacceptable consequences. The Reactor Safety Analysis Report was used as the basis of this investigation. The test plan included very restrictive meteorological requirements to minimize the radiological hazards from the excursion. In addition, an extensive personnel and environmental monitoring program was developed to measure the release of radioactivity and to use the release to conduct additional studies on monitoring techniques. This included cloud tracking by aircraft, air samples, film badges, fallout plates, vegetation and soil samples, and particle size determinations -- all coordinated on a carefully designed sampling grid.

Section II.A.12 provides a complete physical description of the facility and the waste handling systems.

(1) First Test Series

The first destruct test[92] occurred on November 5, 1962. The excursion reached a maximum power of 2,300 MW and a nuclear energy release of 30.7 MWsec. During the excursion considerable damage occurred to the control rod extensions, the core support structure, TV cameras within the reactor building, and various temperature and pressure sensors within the reactor tank. There was gross damage to the core; an estimated 2,000 gallons of water were expelled from the reactor vessel.

(a) Atmospheric Release

The total release was calculated to be 3.6×10^4 Ci or about 0.7% of the 5×10^6 Ci produced from a 31-MWsec excursion. Analysis of gamma spectra indicated that (from 15,000 to 90,000 sec after the excursion) practically all the activity consisted of the daughters of xenon-139, krypton-91, and krypton-92. It is assumed that the other noble gases were released in the same fraction, although their daughters' half-lives were so short they could not be identified. This leads to an estimate that 7.2% of the noble gases produced by the excursion were released to the atmosphere. Although radioiodines were not detected, the maximum possible release which could have gone undetected was calculated to be less than 0.01% of the total radioiodines produced. Although water was spewed from the reactor and gross damage occurred, over 99% of the fission product inventory was retained in or near the reactor vessel. Of the fraction that was released, the activity had decayed by a factor of 100,000 one day after the excursion.

The maximum radiation exposure recorded on film badges located 3,300 ft downwind from the reactor was 20 mrem of gamma. The distance downwind to the INEL boundary is approximately 25 miles; milk samples taken at a farm 30 miles from SPERT-I showed no change in radioactivity levels following the test when compared with samples taken prior to the test[93].

Only very low-level contamination was detected in the immediate vicinity of the reactor; consequently, there was essentially no spread of radioactivity either during reentry for sample recovery or during cleanup operations.

(b) Liquid Discharge

Since most of the activity was due to short half-life isotopes from a relatively new core, activity levels in the reactor coolant water were very low, and the water was discharged to a seepage pond. Radioactivity in the water that was ejected from the reactor to the exterior of the building during the excursion was also low enough that removal of soil surrounding the reactor building was not necessary.

(c) Solid Waste Disposal

All damaged reactor components were either decontaminated if salvageable or properly packaged and transported to the INEL Radioactive Waste Management Complex. Solid waste (rags, blotting paper, etc.) generated during cleanup operations also was sent to the complex. There were no personnel exposures during either the test or the posttest activities in excess of the daily administrative guide limit of 60 mrem.

(2) Second Test Series

The primary objective of the second test was the study of the nature of the destructive effects which could be produced as a result of a severe power excursion in a low-enrichment oxide core. The second destruct test took place on November 10, 1963 with a total nuclear energy release of 155 MWsec. During this excursion 2 of the 590 fuel pins in the core ruptured. No significant mechanical damage to the core resulted from this test.

(a) Atmospheric Release

The total release was calculated to be 530 Ci or about 0.002% of the 2.4 x 10^7 Ci produced from a 155-MWsec excursion. Analysis of gamma spectra indicated that (from 15,000 to 70,000 sec after the excursion) practically all the activity consisted of daughters of krypton-91, krypton-92, and xenon-139; thus, about 0.02% of the noble gases produced were released to the atmosphere. No iodines were detected in this test; however, estimates based on detection limits for iodine-131 and iodine-135 indicated that maximum possible releases for these two isotopes were both less than 0.01%. Concentrations of airborne radioactivity appeared to be a factor of 100 less than the first test, and the release fraction a factor of 350 less, although the nuclear energy release was about five times as great.

(b) Liquid Discharge

There was no significant increase in activity levels of liquids discharged routinely to the SPERT-I seepage pond.

(c) Solid Waste Disposal

Since there was very little damage to reactor components, the only solid waste generated was that due to decontamination activities. These wastes were packaged and transported to the INEL Radioactive Waste Management Complex.

(3) Third Test Series

Since the second test did not produce widespread cladding failure, the third test was modified in the hope of accomplishing the same objective. The third destruct test took place on April 14, 1964 with an energy release of 165 MW. Again, no significant mechanical damage occurred in the core or to instrumentation.

(a) Atmospheric Release

Aerial monitoring was conducted as in the previous tests. Radiation levels of 0.2 mR/hr were recorded at the SPERT exclusion fence 0.5 mile away and the cloud was tracked about 2.5 miles, at which point levels had dropped to background. It was estimated that about 1900 Ci of noble gases were released to the atmosphere, which is about 0.06% of the noble gases produced from a 165-MW excursion and about 0.006% of the total fission product inventory.

(b) Liquid Discharge

As was the case in the other tests, there was no significant increase in the quantity or radioactivity of liquid waste discharge as a result of the test.

(c) Solid Waste Disposal

A small quantity of contaminated equipment and miscellaneous decontamination materials was packaged and shipped to the INEL Radioactive Waste Management Complex.

f. The SNAPTRAN Destructive Testing Program

As part of the U. S. space effort, a number of small nuclear reactors were developed to supply auxiliary power for space vehicles. These Systems for Nuclear Auxiliary Power (SNAP) reactors posed unique nuclear safety problems, since the reactors could not be provided with the usual engineering safeguards because of weight limitations (such as biological shielding). The ERDA therefore established, as part of its overall nuclear safety effort, a test program to determine the radiological consequences of potential nuclear incidents involving these reactors.

The effort consisted of a series of safety tests, designated the SNAPTRAN program, and culminated in subjecting the test versions of two SNAP 2/10A reactors to severe reactivity insertions, which resulted in their complete disassembly. The first of these two tests, SNAPTRAN-3, was designed to provide information on the radiological consequences of the accidental immersion of a SNAP 2/10A reactor in water or wet earth such as could occur during assembly, transport, or a launch abort. The second of these tests, SNAPTRAN-2, was designed to provide information on the dynamic response, fuel behavior, and inherent shutdown mechanisms of these reactors in an open air environment.

This program was conducted on an outdoor test pad at the IETF, which is located about 1 mile north of the TSF complex. Section II.A.12 gives a detailed description of the IETF and associated waste handling facilities.

The SNAPTRAN 2/10A reactor was a modified SNAP 2/10A flight system reactor. The core was composed of six beryllium inserts and 37 fuel rods arranged in a closely packed hexagonal array containing 4.75 kg of uranium-235 and 928 g of hydrogen.

An extensive monitoring program was undertaken to measure and evaluate the radiological consequences of the destruct tests. Monitoring was provided for quick assessment of test hazards in order to ensure that no offsite hazard to the public occurred. The program included fixed, mobile, and aerial monitoring units utilizing many different sampling and dosimetry devices. In addition, strict meteorological requirements were imposed to preclude unacceptable radiological risks to either on- or offsite populations.

(1) First Destructive Test

On April 1, 1964, the SNAPTRAN 2/10A-3 water immersion destructive test[94] was conducted to simulate the water immersion type of accident. The reactor was housed in an environmental tank; the tank was sized to simulate a large body of water and still remain small enough to facilitate the necessary measurements and evaluations. The estimated total nuclear energy released during the test was on the order of 45 MWsec.

(a) Atmospheric Release

Water and steam were ejected in a spherical cloud directly above the environmental tank. Most of the water fell back into the environmental tank, after which a visible, vapor filled cloud was blown downwind. Following collapse of the water, a second cloud arose and merged with the first within 80 ft of the reactor. A monitoring airplane intercepted the cloud at approximately 1 mile from the test site and followed it for 21 miles before the cloud dispersion and radioactive decay reduced the radiation levels to background.

More than 99% of the fission products were retained in the environmental water and reactor fuel remains. The halogens that escaped from the fuel also were retained in the water; consequently, no airborne iodine was detected. The only fission products detected in the cloud were noble gases and their daughters. It was calculated that on the order of 3% of the noble gases generated during the excursion was released, or approximately 24,000 Ci. Sensitive monitors revealed no airborne beryllium contamination in the cloud or in the vicinity of the reactor. The total integrated radiation exposure dose at the nearest INEL boundary (6 miles) was less than 10 mrem. Only slight ground contamination was detected in the test area. General area contamination approached background levels three days after the test.

(b) Liquid Discharge

Of the 10,000 gallons of water originally in the environmental tank, all but about 500 gallons returned to the tank following the original power burst. The tank was rapidly drained to the IET underground liquid waste holding tank, allowed to decay, and then transported to the ICPP for further treatment and storage.

(c) Solid Waste Disposal

There was very little dispersion of radioactive debris in the vicinity of the test area, and no beryllium contamination was detected. Use of a new core and a limited release of fission products also accounted for a minimal amount of solid waste being generated from the test or subsequent cleanup and decontamination activities. That which was generated was properly packaged and transported to the INEL Radioactive Waste Management Complex.

(2) Second Destructive Test

In January 1966, the second destructive test[95] was conducted, this time in an open air environment. This test produced gross core disassembly, causing pieces of fuel to be scattered as far as 700 ft from the reactor. A total of 54 MWsec of nuclear energy was released during the test.

(a) Atmospheric Release

A visible smoke filled cloud arose immediately following the test. This cloud reached a height of 100 ft after it had traveled 70 ft downwind and leveled off at about 175 ft high by the time it had reached 300 ft downwind. The cloud was monitored by aircraft and ground level telemetering stations as it moved downwind beyond the INEL boundary (6 miles). The noble gas cloud was monitored out to a distance of about 19 miles, at which point radiation levels were not distinguishable from background radiation.

The fission product release from this test was considerably higher than that released from the SNAPTRAN-3 underwater test. Approximately 75% of the noble gases, 70% of the halogens, 45% of the tellurium, and 4% of the remaining solids were released. This represents an approximate release of 6×10^5 Ci of noble gases and 0.1 Ci of iodine-131.

Widespread dispersal of fuel and beryllium resulted in the immediate test area being extensively contaminated, but this was limited primarily to within a radius of 300 ft. Because of the highly toxic nature of the beryllium, special air samples were recovered immediately after the test, but only background levels were detected. Once again the total integrated radiation exposure dose at the nearest INEL boundary was less than 10 mrem, and all surface contamination was limited to a radius of 700 ft from the test pad.

(b) Liquid Discharge

Since the test was an open air excursion, no liquid wastes were generated other than small quantities of decontamination agents, which were disposed of via the IET radioactive liquid waste system.

(c) Solid Waste Disposal

The core characteristics, energy release, and corresponding available fission products were of the same order of magnitude for the first and second tests. However, as described above, the differences in test conditions resulted in a significant increase in the physical destruction of the reactor and the release of the available fission product inventory. Consequently, the quantity of solid wastes generated was considerably greater for the second test. Again, the majority of the radioactivity was short half-life materials which decayed rapidly. There was, however, within a radius of 700 ft from the test site, a considerable quantity of soil contaminated with fission products and uranium and beryllium particles. This area was cleaned completely, and a total of approximately 300 yd^3 of soil was transported to the INEL Waste Management Complex for disposal. Some lesser quantities of scrap metal and decontamination materials were packaged and transported to the Radioactive Waste Management Complex. The IET area is now an idle facility, but it can be used if necessary as there is no residual radioactive contamination.

g. <u>Controlled Environmental Radioiodine Test (CERT) Program</u>

The CERT[96,97,98,99] program consisted of a series of planned atmospheric releases of radioiodine under varying conditions of meteorology, vegetation type, chemical form, and distance.

The primary objective of the project was to determine the quantitative behavior of radioiodine as it passes through the air-vegetation-cow-milk-human chain. To this end, measurements have included deposition velocities (air-ground ratios), milk-to-grass activity ratios, half-lives of radioiodine in milk and on grass, portable instrument readings relative to contamination levels, and human thyroid uptake fractions. The passage of radioiodine through a segment of the biosphere is influenced by many factors. The CERT program was intended to define these factors as they apply to the INEL and its environs, and to reveal which factors are most significant. The resulting data are of operational use at the INEL in the development and review of reactor siting criteria, safety analysis report preparation, and emergency planning and response.

Preliminary experiments were begun in May and June of 1963 near the southern boundary of the INEL, in an area which had been planted in crested wheatgrass. During the summer of 1963, construction began on an experimental field station located about 7 miles northeast of the ICPP. The area was chosen because of the availability of land, the existence of an adequate well, safety considerations, and relative accessibility. A 27-acre plot was leveled, diked, and fenced. A dairy barn, pumphouse, sprinkler system, and corral were constructed and pasture grass was seeded. The remainder of the field tests of the CERT program were conducted at or in conjunction with this facility. In all, 27 tests were conducted between 1963 and 1969. No further tests have been conducted; however, the facility is still functional and future tests are contemplated.

On CERT tests 1 through 7, up to 1.0 Ci of iodine-131 was released to the atmosphere at the experimental field station, with the exception of test 6, where 2 to 6 Ci were released through the ICPP 250-ft-high stack. Tests 8 through 20 involved the release of up to 1.0 Ci of iodine-131 per test. Test 21 involved direct feeding to the cows with no atmospheric release. Finally, tests 22 through 27 involved two more metabolism studies (no air release), three 500-mCi noniodine releases (chromium-51 or potassium-42), and two more iodine releases.

In all cases the release quantities were well within exposure guidelines. Since the released isotopes were all very short half-life materials, any residual contamination since the last test in 1969 has long since decayed to background.

12. Environmental Monitoring Program

An environmental monitoring program was established in the early 1950s to characterize the routine, programmatic, and accidental releases from INEL nuclear testing. This program is carried out by the ERDA's HSL, the USGS, and the NOAA. Monitoring programs have been improved since inception of the program as new instruments and techniques have become available. The HSL environmental monitoring results are reported once a year. Reports on the USGS monitoring program are made periodically[76].

Groundwater is sampled biweekly by HSL personnel at 22 production wells on the INEL, and analyses for radioactivity are performed. Twice each year 12 wells outside the INEL boundaries are sampled and analyzed for radioactivity. The locations of the wells sampled are shown in Figures II-70 and II-71.

A continuous air sampling program is maintained at nine onsite and ten offsite locations as shown in Figure II-72. Samples are changed weekly and analyzed for radioactivity. The concentrations of suspended particulate material also are determined for these samples. Natural dustfall rates are measured routinely. A program for monitoring sulfur dioxide and nitrous oxide concentrations in air at locations on and near the INEL was put into operation in 1972. Analytical results verify those of diffusion calculations, which indicate that sulfur dioxide and nitrous oxide concentrations are well below standards established by the EPA[42].

In order to establish background levels of natural and fallout radioactivity in surface soil and to assess any potential buildup of activity from INEL site operations, soil samples were collected from four distant and nine boundary locations during 1971, 1973, and 1974, (Figure II-73). Soil samples collected in 1971 and 1973 represented a composite of five plugs of soil from a 1-m^2 area. Each plug was a cylinder 10 cm in diameter and 5 cm in depth. In 1974 a 10-m^2 area was sampled for each composite. A number of 5- to 10-cm depth samples were also collected to determine the relative distribution of radioactivity in two depth increments. All soil samples were analyzed for gamma-emitting radionuclides. Some were also analyzed for Sr-90 and alpha-emitting nuclides. The data are reported in units of activity per gram of soil sampled (μCi/g dry weight) and also in units of areal activity (nCi/m^2), which is the total activity in each soil sample divided by the surface area (0.039^2) of the soil sample.

Sampling of animals (primarily jackrabbits and antelope) and plants (mainly sagebrush) is conducted by the HSL on an intermittent basis for uptake of radionuclides. The animals represent a sensitive indication of the levels of radionuclides from fallout of INEL effluents on vegetation. Gamma scans are performed on samples of antelope lung tissue, muscle tissue, liver tissue, and rumen to determine uptake of radionuclides. Thyroid and bone samples are analyzed for iodine-131 and strontium-90, respectively.

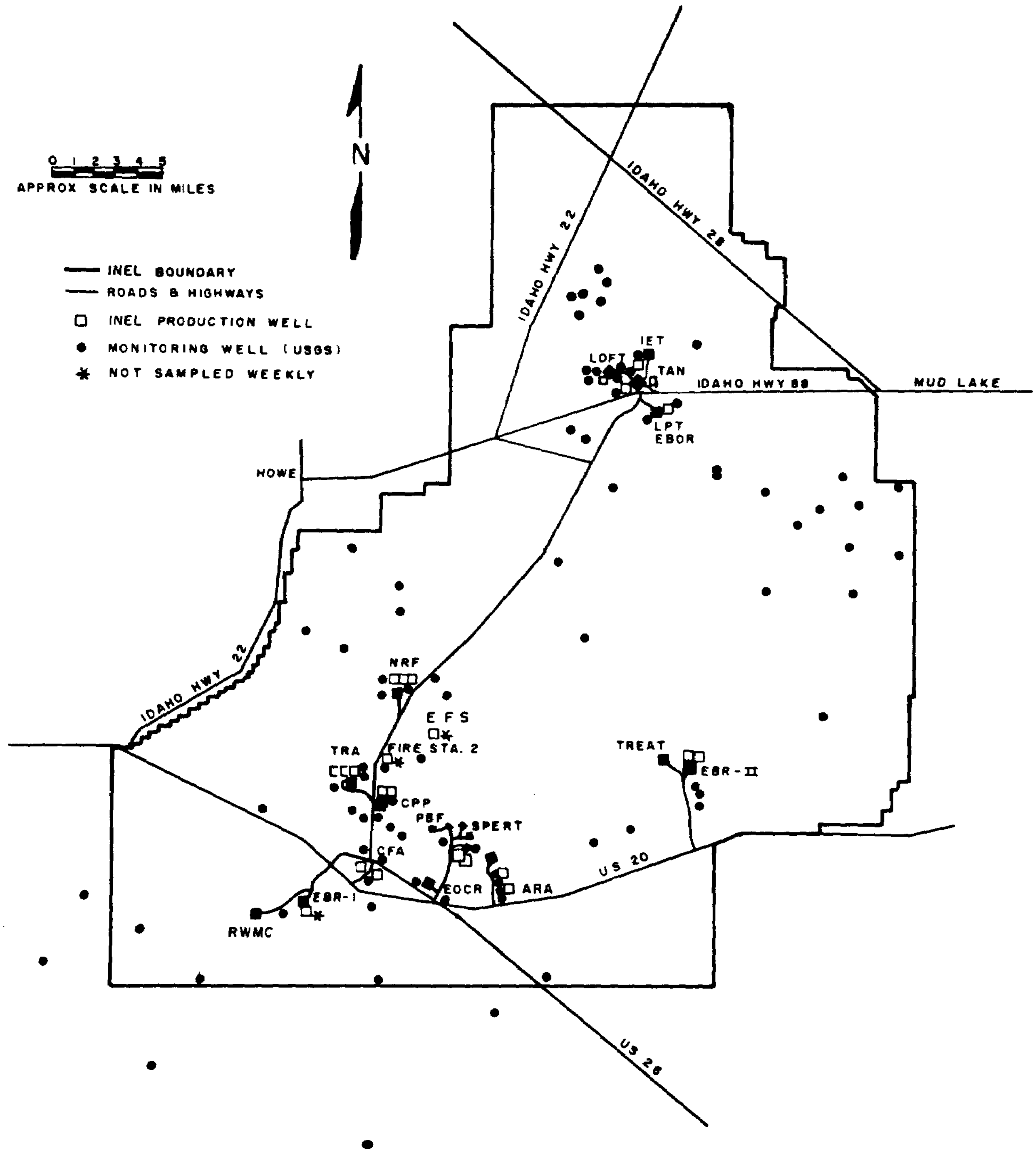

Figure II-70. INEL Production and Monitoring Wells.

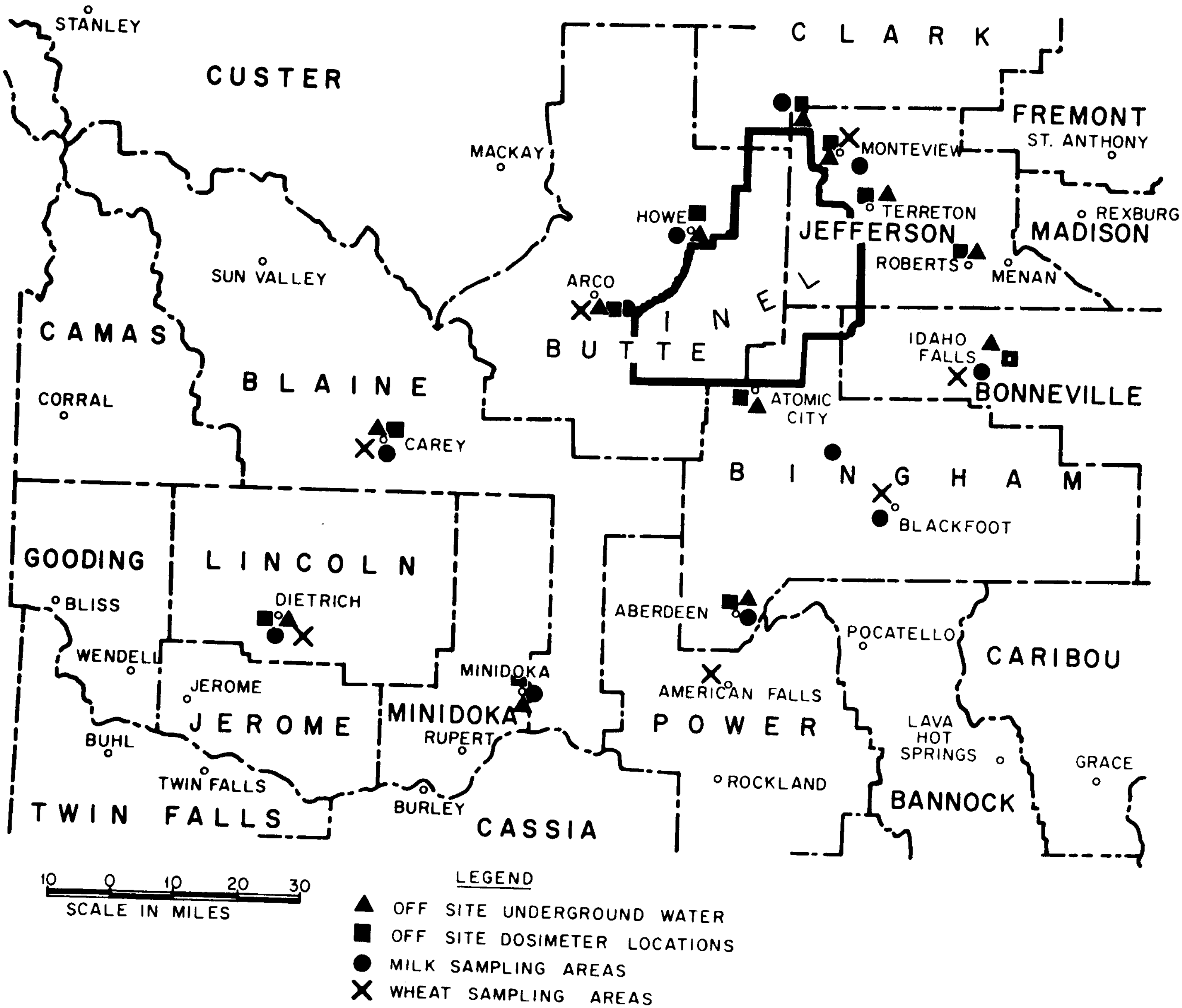

Figure II-71. Radiological and Monitoring of INEL Environs.

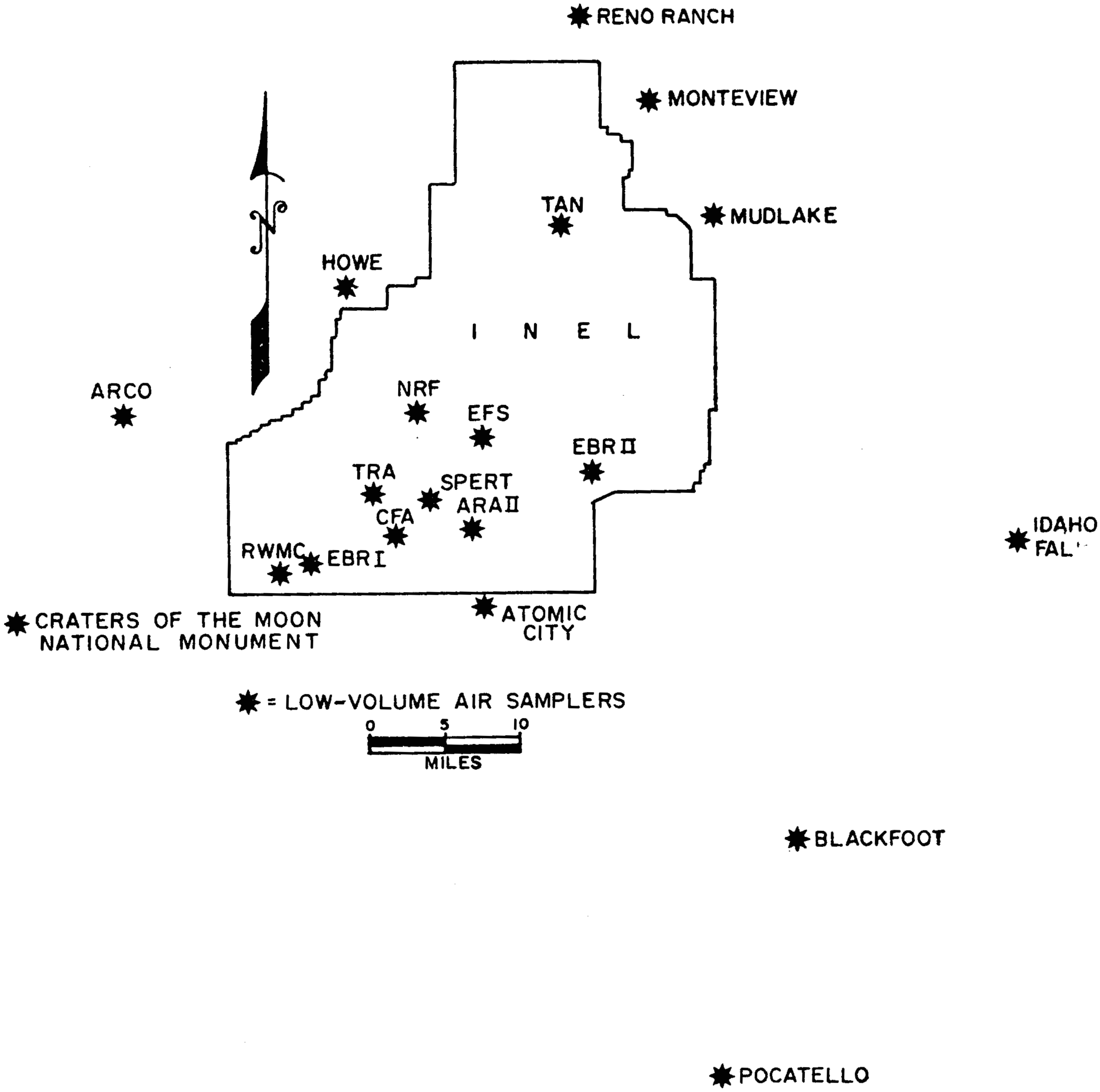

Figure II-72. INEL Air Sampling Network.

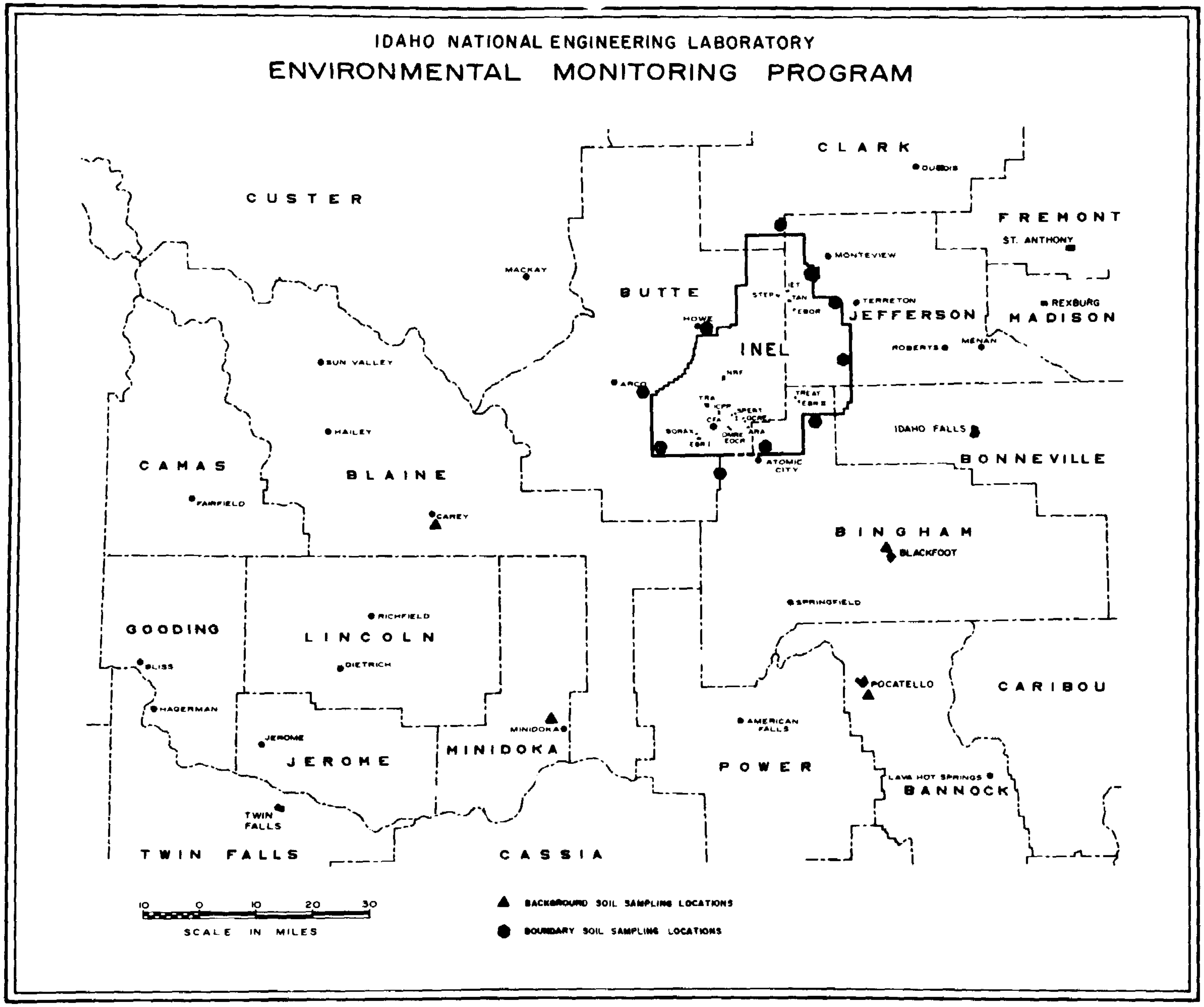

Figure II-73. Locations of INEL Boundary and Background Soil Samples.

Samples of foodstuffs produced near the INEL which are known to be important in the transfer of radionuclides to man are collected routinely and analyzed for specific radionuclides (iodine-131, cesium-137, and strontium-90). Grade A and Grade B milk samples are obtained weekly and monthly, respectively, from locations indicated in Figure II-71. Wheat is sampled at harvest time each year; sampling locations also are shown in Figure II-71.

A summary of the water, milk, and wheat sampling frequency, along with applicable counting data, are presented in Table II-61. Table II-62 presents the same information for the air monitoring program.

In addition to the aforementioned HSL sampling program, the USGS samples groundwater. During 1974, some 800 chemical and radiochemical analyses were performed on about 300 samples. These analyses provide a part of the information upon which periodic reports dealing with the Snake River Plain aquifer are based. Water level measurements, Big Lost River discharge measurements, and other hydrologic and geologic data are obtained and reported by the USGS. In addition, samples of fish and bottom dwelling organisms which would tend to concentrate any radionuclides, if present, are being collected and analyzed.

There is also an environmental monitoring program conducted at the Radioactive Waste Management Complex (RWMC) and the SL-1 Burial Ground. This monitoring program is summarized in Table II-63. There are both periodic and random sampling of the atmosphere, hydrosphere, and lithosphere to provide an assessment of the RWMC operations upon the enviroment. The data in Table II-63 pertain to the RWMC unless direct reference is made to the SL-I Burial Ground.

The USGS and NOAA maintain staffs at the INEL to serve as consultants to ERDA and its contractors and to perform independent studies. Further, the ERDA headquarters staff performs its own periodic appraisal of waste management activities at all field offices. The last such appraisal of waste management practices at the INEL was made in July 1976

In addition, reviews of waste management practices at INEL have been made by the following outside organizations:

(a) U. S. Environmental Protection Agency (formerly Federal Water Quality Administration): October 1968[a], January 1974

(b) U. S. Public Health Service: November 1969[a]

(c) U. S. General Accounting Office: November 1968[a], November 1969[a], and August 1970

(d) Special Governor's Task Force, State of Idaho, January 1970

(e) National Academy of Science: July 1960[a], May 1965[a], and April 1969[a].

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[a] Formal report prepared.

TABLE II-61

INEL ENVIRONMENTAL MONITORING PROGRAM FOR WATER, MILK, AND WHEAT

WATER

Nuclide	Monitoring Frequency	∿ Sample Size (ml)	Count Time (min)	∿ Detection Limits (μCi/ml)	% RCG 0524-Table II
Gross Beta	*	250	20	5×10^{-9}	17**
Gross Alpha	*	100	60	3×10^{-9}	10
H-3	*	10	20	400×10^{-9}	0.01
Sr-90	M, ICPP	4000	20	0.8×10^{-9}	0.3

* - Onsite locations monthly, offsite locations semiannually.

** - Based on most restrictive beta emitter (Ra-228).

MILK

Nuclide	Monitoring Frequency	∿ Sample Size (ml)	Count Time (min)	∿ Detection Limits (μCi/ml)	% FRC Guide
I-131	M,S : W,S	3800	1000	1×10^{-9}	1
Sr-90	Y,A	3800	20	1×10^{-9}	0.5
H-3	Y,A	3800	100	400×10^{-9}	not established

M,S : W,S - some monthly samples, some weekly samples.

Y - yearly samples.

WHEAT

Nuclide	Monitoring Frequency	∿ Sample Size (g)	Count Time (min)	∿ Detection Limits (pCi/g)	No Guide Established
Sr-90	Y,A	2500	20	0.004	
Cs-137	Y,S	2500	1000	0.004	

TABLE II-62

INEL ENVIRONMENTAL PROGRAM FOR AIR

Nuclide	Monitoring Frequency	∿ Sample Size (m^3)	Count Time (min)	∿ Detection Limits (μCi/ml)	% RCG 0524 Table II
Gross beta	W,A	330	20	8×10^{-15}	0.8
Pu-239	Q,S	4000	1000	10×10^{-18}	0.02
Ce-144	Q,A	4000	60	17×10^{-15}	0.009
Ru-106	Q,A	4000	60	18×10^{-15}	0.009
I-131	W,A	330	20	8×10^{-15}*	0.008
Pu-238	Q,S	4000	1000	6×10^{-18}	0.009
Sr-90	Q,S	4000	20	1.8×10^{-15}	0.006
H-3	M,S	10	100	1×10^{-11}	0.003
Am-241	Q,S	4000	1000	6×10^{-18}	0.003
Zr-95	Q,A	4000	60	14×10^{-15}	0.001
Co-60	Q,A	4000	60	2×10^{-15}	0.0007
Sb-125	Q,A	4000	60	6×10^{-15}	0.0007
Cs-137	Q,A	4000	60	3×10^{-15}	0.0006
Ce-141	Q,A	4000	60	9×10^{-15}	0.0002
Ru-103	Q,A	4000	60	6×10^{-15}	0.0002
Mn-54	Q,A	4000	60	2×10^{-15}	0.0002
Cs-134	Q,A	4000	60	2×10^{-15}	0.00005

Q - quarterly composites of weekly samples.
W - weekly samples.
M - monthly samples.
A - all locations.
S - some locations only.
* - makes the improbable assumption that the charcoal filters collect all the airborne iodine.
** - based on the most restrictive beta emitter (Ra-228).

TABLE II-63

ENVIRONMENTAL MONITORING PROGRAM AT THE RWMC AND THE SL-1 BURIAL GROUND

Sample Type	Description of Sampling Method	Sampling Frequency	Required Number of Samples
Gamma radiation background levels in the INEL RWMC and SL-1 Burial Ground	20-foot boom with 18 GM tubes	Annually	High reading recording in each 50-foot survey grid
Perimeter Monitor	Thermoluminescent dosimeter	Biannual	1 biannually at 18 stations
Soil Samples	Take samples at surface, 15-cm and 30-cm depths	Minimum of 25 samples annually taken at randomly selected locations in and near work areas and other selected areas	Minimum of 25 samples
Air Samples	Low volume air samplers ($\sim$1 cfm) and Hi-Volume 20-40 cfm samplers	RWMC perimeter-continuous sampling; sampling of the pits and trenches during the day shift working hours	[a]
Water Samples Surface	Collect 500-ml samples to INEL stores standard 550-ml poly bottles	After periods of heavy rainfall or snow melting	Depends on the situation-sample TSA pad, Pad A, and any water that collects in pits
Moisture Probes Subsurface	Insert miosture probe to the bottom of the 23 sample holes at the RWMC and SL-1 Burial Ground	After spring thaw and in late fall before major frosts and other selected times	Twenty-three sample holes (16) INEL RWMC (7) SL-1 Burial Ground
Water Samples Subsurface	Collect 500 ml of water from sample holes if water is present	Same as above it water is found in the sample holes	Sample each hole which contains water
Sample 250-foot Well and the four 600-foot wells	Collect 550 ml of water from the well in an INEL stores standard 550-ml bottle (poly type)	Semiannually	Two samples per year per well
Periodic Visual Inspection	Tour INEL RWMC and SL-1 Burial Ground visually inspect	Monthly	Not applicable
Vegetation	Collect	Annually	1/2 to 1 dozen
<u>Experimental Programs</u>			
Subsurface Soil Samples	Collect samples under and adjacent to old waste	Whenever opportunity present from on-going operations	As available
Storage Cell Monitoring	Temperature and moisture Electronic probes	By continuous recorder	Continuous recording

[a] Air Samples A minimum of three samples will be operated continuously on the north side of the RWMC and three air samplers operated continuously on the south side of the RWMC.

13. Environmental Gamma Exposures

Environmental gamma radiation exposures are measured with thermoluminescent dosimeters placed at the INEL boundary and surrounding communities. Exposures at the distant Idaho locations of Roberts, Blackfoot, Aberdeen, and Minidoka are considered to be the normal background level for the area. Measurements of boundary community exposures are made at Atomic City, Howe, Arco, Butte City, Mud Lake, Monteview, and Reno Ranch. The environmental background ionizing radiation exposure rate measured in the environs surrounding the INEL are comparable to the background at more distant locations. The predicted annual whole body background dose near the INEL site is given in Table II-64.

TABLE II-64

ESTIMATED ANNUAL WHOLE BODY BACKGROUND DOSE NEAR THE INEL SITE

Source	Annual Dose (mrem)
Terrestrial and Ionizing Cosmic (measured by thermoluminescent dosimeters)	110
Cosmic (neutrons)	15
Internal Emitters (K-40 and others)	25
Total	150